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PRESENT STATUS AND PROBLEMS OF TESTS AND RESEARCH ON AGRICULTURE, FORESTRY AND FISHERIES

- Plant Diseases and Insect Pests -

Norin Suisangyo ni Kansuru Shiken
Kenkyu no Genjo to Mondaiten
(English version above), Tokyo,
June 1963, pages 1-88

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I. Research Organizations on Insect Pests in National Experimental Laboratories

A. Agricultural Technical Laboratories

Department of Pathology and Insects:

1. Pathology Division:

a. First Bacterial Disease Laboratory (Research on classification of bacterial disease)

b. Second Bacterial Disease Laboratory (Research on treatment of bacterial disease and ecological aspects of pathogenic bacteria)

c. First Viral Disease Laboratory (Research on classification of viral disease)

d. Second Viral Disease Laboratory (Research on treatment of viral disease)

e. First Cladothrix Disease Laboratory (Research on ecological aspects of Cladothrix disease in field crops)

/A.T.L. and A.E.L. without any place name denote the Tokyo location of the particular laboratory/

f. Second Cladothrix Disease laboratory (Research on ecological aspects of Cladothrix paddy rice disease)

g. Third Cladothrix Disease Laboratory (biochemical research on diseases of principal crops)

2. Insect Division:

a. First Insect Pest Prevention and Elimination Laboratory (Research on insect pest nutrition and crop damage caused by insect pests)

b. Second Insect Pest Prevention and Elimination Laboratory (Research on methods of surveying insect pest growth and causes of insect variation)

c. Third Insect Pest Prevention and Elimination laboratory (Research on effectiveness of new insecticides against chief insect pests and methods of application)

d. Insect Outbreak Prediction laboratory (Research on the mechanism of insect pest outbreaks and their prediction)

e. Insect Identification and Classification laboratory (Research on identification and classification of harmful and useful insects)

f. Nematoda Laboratory (Research on classification, prevention, and elimination of harmful Nematoda)

3. Insecticide Division:

a. First Insecticide and Chemical laboratory (Research on insecticide improvement and use)

b. Second Insecticide and Chemical Laboratory (Research on germicide improvement and use)

c. Third Insecticide and Chemical Laboratory (Research on improvement and use of supplementary agents)

d. Insecticide Laboratory on Physics and Chemistry (Research on new insecticides involving physics and chemistry)

e. Insecticide Laboratory on Biophysics and Biochemistry (Research on new insecticides involving biophysics and biochemistry)

B. Agricultural Experimental Laboratories

Environmental Department

a. First Disease Laboratory (Research on prevention and treatment of principal crop diseases)

b. Second Disease Laboratory (Research on ecological aspects, prevention, and treatment of sweet potato diseases)

c. First Insect Damage Laboratory (Research on insect prevention and elimination of paddy rice and field crop insect pests)

d. Second Insect Damage Laboratory (Research on prevention and elimination of Nematoda crop pest)

C. Domestic Animal Experimental Laboratories

Fodder Crop Department

Fifth Feeding Crop Laboratory (Research on disease prevention and treatment of fodder crops and pastures)

D. Horticulture Experimental Laboratories

Second Department of Fruit Trees

a. Fruit Insect Pest Outbreak Prediction Laboratory (Research on predicting outbreaks of

insect pests of deciduous fruit trees) in Hiratsuka

b. Fruit-Tree Disease Outbreak Prediction Laboratory (Research on predicting outbreaks of deciduous fruit tree disease) in Hiratsuka

c. Orange Disease Laboratory (Research on disease prevention and treatment of orange varieties) in Kozu

d. Orange Insect Damage Laboratory (Research on prevention and elimination of various insects in oranges varieties) in Kozu

Morioka Branch

a. Disease Laboratory (Research on disease prevention and treatment of horticultural crops)

b. Insect Damage Laboratory (Research on prevention and elimination of insect pest in horticultural crops)

Kurume Branch

a. Insect Damage Laboratory (Research on prevention and elimination of insect pest in horticultural crops)

E. Tea Experimental Laboratory

Cultivation Department

a. Disease Laboratory (Research on disease prevention and treatment of tea trees)

b. Insect Damage Laboratory (Research on prevention and elimination of insect pests on tea trees)

F. Hokkaido Agricultural Experimental Laboratory

<u>Department of Pathology and Insects</u>

a. First Disease Laboratory (Research on disease resistance of the potato plant)

b. Second Disease Laboratory (Research on chief crops, horticultural crops, and industrial crops)

c. First Insect Damage Laboratory (Research on insect pest prevention and elimination of insect pest in main crops, horticultural crops, and industrial crops)

d. Second Insect Damage Laboratory (Research on prevention and elimination of harmful animals and insects in soil)

<u>Farm Field Cultivation Department</u>

a. Field Insect Damage Laboratory (Research on insect pest prevention and elimination of field crop insect pests)

G. Tohoku Agricultural Experimental Laboratory

<u>First Cultivation Department</u>

a. First Disease Laboratory (Research on disease resistance of paddy rice)

b. Second Disease Laboratory (Research on outbreaks, ecological aspects, prevention, and treatment of diseases of paddy rice and secondary paddy field crops)

c. Insect Damage Laboratory (Research on prevention and elimination of insect pests of paddy rice and secondary paddy field crops)

<u>Second Cultivation Department</u>

a. Farm Field Disease Laboratory (Research on occurrence, ecological aspects, prevention, and treatment of field crop diseases)

b. Farm Field Insect Damage Laboratory (Research on prevention and elimination of field crop insect pests)

H. Hokuriku Agricultural Experimental Laboratory

Environmental Department

a. First Disease Laboratory (Research on disease resistance of main crops)

b. Second Disease Laboratory (Research on outbreak, ecological aspects, prevention, and treatment of main crop diseases)

c. Insect Damage Laboratory (Research on prevention and elimination of main crop insect pests)

I. Tokai-Kinki Agricultural Experimental Laboratory

First Cultivation Department

a. Disease Laboratory (Research on disease prevention and treatment of main crops)

b. Insect Damage Laboratory (Research on prevention and elimination of main crop insect pests)

J. Chukoku Agricultural Experimental Laboratory

Cultivation Department

a. First Disease Laboratory (Research on disease resistance of paddy rice and wheat)

b. Second Disease Laboratory (Research on disease prevention and treatment of main crops)

c. Insect Damage Laboratory (Research on prevention and elimination of main crop insect pests)

K. Shikoku Agricultural Experimental Laboratory

<u>Cultivation Department</u>

a. Disease Laboratory (Research on prevention and treatment of main crop diseases)

b. Insect Damage Laboratory (Research on prevention and elimination of main crop insect pests)

L. Kyushu Agricultural Experimental Laboratory

<u>First Environmental Department</u>

a. First Disease Laboratory (Research on outbreak and ecological aspects of main crop diseases)

b. Second Disease Laboratory (Research on prevention and treatment of main crop diseases)

c. First Insect Damage Laboratory (Research on outbreak and ecological aspects of main crop insect pests)

d. Second Insect Damage Laboratory (Research on prevention and elimination of main crop insect pests with chemicals)

e. Third Insect Damage Laboratory (Research on insect pests outbreak prediction in warm areas)

<u>Farm Field Department</u>

a. Farm Field Disease Laboratory (Research on prevention and treatment of field crop diseases near the coastal sea of southern Kyushu)

M. Sericultural Experimental Laboratory

<u>Pathology Department</u>

a. Mulberry Disease Laboratory (Research on

outbreak, ecological aspects, prevention, and treatment of mulberry diseases)

b. Insect Pests Laboratory (Research on mulberry tree insect pests and their prevention and methods of elimination)

c. Granular Disease Laboratory

d. Malcosis Laboratory

e. Sclerosis Laboratory

f. Sericultural Viral Disease Laboratory

Tohoku Branch

a. Pathology Laboratory (Research on pathogens, insect pests and prevention and methods of eliminating mulberry tree insect pests)

Chubu Branch

a. Pathology Laboratory (Identical research structure as Tohoku Branch)

Kansai Branch

a. Pathology Laboratory (Identical research structure as Tohoku Branch)

Kyushu Branch

a. Pathology Laboratory (Identical research structure as Tohoku Branch)

N. Forestry Experimental Laboratory

Protection Department

1. Tree Disease Division:

a. Tree Disease Laboratory (Research on physiological phenomena of tree diseases)

b. Bacterial Laboratory (Research on timber decay and Micrococcus versicolor)

2. Insect Division:

a. First Insect Laboratory (Research on physiological and ecological aspects of leaf-eating insects)

b. Second Insect Laboratory (Research on ecological aspects of timber-perforating insects)

3. Bird and Mammal Division:

a. First Bird and Mammal Laboratory (Research on prevention and treatment of damage caused by wild birds and mammals)

b. Second Bird and Mammal Laboratory (Research on protection of wild birds and mammals)

<u>Kiso Branch</u>

a. Protection Laboratory (Research on insect pests prevention and treatment of seedling beds, forests, and virgin lands)

<u>Hokkaido Branch</u>

1. Protection Department:

a. Wild Rat Laboratory (Research on prevention of damage caused by wild rats and harmful animals)

b. Insect Laboratory (Research on damage prevention and ecological aspects of forest insects)

c. Tree Disease Laboratory (Research on tree diseases and bacteria)

<u>Tohoku Branch</u>

1. Protection Department:

a. First Protection Laboratory (Research on prevention and treatment of tree diseases)

b. Second Protection Laboratory (Research on prevention and treatment of insect damage in forests)

Kansai Branch

a. Protection Laboratory (Research on prevention and elimination of insect pests in seedling beds, forests, and virgin lands)

Shikoku Branch

a. Protection Laboratory (Research on prevention and elimination of insect pests in forests)

Kyushu Branch

a. First Protection Laboratory (Research on prevention and treatment of forest diseases)

b. Second Protection Laboratory (Research on prevention and elimination of insect pests in forests)

O. Foodstuff Laboratory

Grain Storage and Processing Department

a. Insect Pests Laboratory (Research on ecological aspects and prevention and elimination of insect pests attacking stored grain)

b. Pathogen laboratory (Research on classification, ecological aspects, prevention, and elimination of microbes in stored grain)

Fermented Food Department

a. Ferment Microbe Laboratory (Research on microbes in fermented food)

II. Organizations for Assigned Experiments Related to Insect Pests*

A. Fukushima Prefectural Agricultural Experimental Laboratory (Prevention and treatment of rice blight disease due to cold climate)

B. Nagano Prefectural Agricultural Experimental Laboratory (Prevention and treatment of rice blight disease)

C. Ibaragi Prefectural Agricultural Experimental Laboratory (Prevention and elimination of field insect pests)

D. Shizuoka Prefectural Agricultural Experimental Laboratory (Prevention and treatment of granular bacteria nucleus rice disease)

E. Shiga Prefectural Agricultural Experimental Laboratory (Prevention and treatment of yellow stunt rice disease)

F. Wakayama Prefectural Agricultural Experimental Laboratory (Prevention and elimination of Acnaria lewisi, Scott)

G. Tottori Prefectural Agricultural Experimental Laboratory (Prevention and treatment of yellow withering wheat disease and leaf withering disease)

H. Yamaguchi Prefectural Agricultural Experimental Laboratory (Prevention and treatment of stripe withering rice disease)

I. Nagasaki Prefectural Agricultural Center (Prevention and elimination of potato insect pests)

J. Kagoshima Prefectural Agricultural Experimental Laboratory (Prevention and elimination of field insect pests)

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*Assigned experiments are supposed to be conducted by government, but the prefectural agricultural laboratories are assigned special projects by the government depending on favorable locations, eminent researchers, and facilities. Experimental expenses are subsidized by the government.

CHAPTER II

GENERAL BACKGROUND OF EXPERIMENTAL RESEARCH

Production of crops and the relationship between crop supply and demand with the requirement of research on prevention and elimination of insect pests can be better understood by studying the present situation of these crops and related problems. Generally, the following concepts are considered: It has been questioned whether or not agriculture in Japan is a truly commercial operation, because the weakest feature of agriculture in Japan is its small scale. Modernization of agriculture requires an expanded scale of management and an increase in productivity by investments of machinery and capital. Up-to-date farming techniques are indeed necessary because cultivated land in Japan is quite limited. For example, commercial farm products require laborious cultivation to be profitable. It is held that agriculture can be commercialized under three economic structures by analyzing and implementing the above concepts. The following policies are required: selective expansion of production (including adequate cultivation on suitable land depending on changes in crop demand structure), expansion of management, mechanization of agricultural processing, and establishment of a policy against agricultural calamities. Consequently, the research problem centers on how research on prevention and elimination of insect pests contributes to the expansion of farming as one phase of agricultural technique.

Observation of variation in insect disease outbreaks is important under the above circumstances.

The following table shows recent trends in disease outbreaks.

Areas of Main Insect Outbreaks or Damage
Area in 1960

[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	
							ha
[illegible]	[illegible]	[illegible]	[illegible]	667,[illegible]	ニカメイチュウ1化期	[illegible]	1,111,000
		[illegible]	〃	64[illegible]	2化期	〃	854,000
		[illegible]	〃	548,[illegible]	サンカメイチュウ1化期	〃	1,000
		[illegible]	〃	6,500	2化期	〃	4,000
		[illegible]	[illegible]	894,000	3化期	〃	20,000
		[illegible]	[illegible]	36,000	[illegible]ジロウンカ	〃	601,000
		[illegible]	〃	96,000	[illegible]ウンカ	〃	405,000
		[illegible]	〃	9,500	[illegible]	〃	882,000
		[illegible]	〃	176,000	[illegible]トビウンカ	〃	200,000
		[illegible]	〃	202,000	[illegible]	〃	106,000
					イネハモグリバエ	〃	98,000
					イネドロオイムシ	〃	123,000
					イネクロカメムシ	〃	26,000
					イネカラバエ	〃	183,000
					コブノメイガ	〃	2,2000
					フタオビコヤガ	〃	125,000
					イネゾウムシ	〃	84,000
					ナワヨトウ	〃	108,000
				ha			ha
[illegible]	1,553,[illegible]	[illegible]	[illegible]	110,000			
		[illegible]	〃	191,000			
		[illegible]	〃	20,000			
		[illegible]	〃	16,000			
		ムギ[illegible]	〃	349,000			
		[illegible]	〃	339,000			
		[illegible]	〃	15,000			
		[illegible]	〃	4,500			
[illegible]	355,[illegible]				ナカジロシタバ	[illegible]	44,000
[illegible]	190,000	[illegible]	[illegible]	4[illegible],000	[illegible]ソトウムシダマシ	[illegible]	28,000
[illegible]	61,000	[illegible]	[illegible]	12,000			
		[illegible]	〃	35,000			
		[illegible]	〃	[illegible]1,000			
[illegible]	56,000	[illegible]	[illegible]	[illegible]5,000			
		[illegible]	〃	20,000			
[illegible]	16,000	[illegible]	[illegible]	6,000			
		[illegible]	〃	8,000			
[illegible]	14,000	[illegible]	[illegible]	5,700			
		[illegible]	〃	4,000			
[illegible]	15,[illegible]	[illegible]	[illegible]	[illegible]			
		[illegible]	〃	5,000			

① [illegible]	② [illegible]	③ [illegible]		④ [illegible]	
		⑤ [illegible]	⑥ [illegible]	⑦ [illegible]	⑧ [illegible]
[illegible]	15,[illegible]	[illegible]	1,[illegible]	[illegible]	1,[illegible]
		[illegible]	4,[illegible]		
[illegible]	[illegible] 2561400	[illegible]	2,000	[illegible]	[illegible] 2,000
		[illegible]	14,[illegible]	[illegible]	57,000
		[illegible]	4,500	[illegible]	23,000
				[illegible]	118,000
				[illegible]	8,500
				[illegible]	184,000
				[illegible]	87,000
				[illegible]	25,000
				[illegible]	51,000
				[illegible]	80,000

Note: The above figures are based on the following data. However, figures for fruit trees are based on 1959 data. Data for areas less than 1,000 hectares is counted as five and higher taken as a unit, with the rest disregarded. The unit ha, hectare is substituted for the unit cho.

1. 37th Statistical table of the Ministry of Agriculture and Forestry (Statistical Survey Department)

2. 1960 Sericultural Statistical Report (Statistical Survey Department)

3. 1960 damage survey report of harmful forest animals and plants (Forestry Agency)

4. The data on insect pest outbreak predictions (Plant Epidemic Prevention Division)

5. Data of Plant Epidemic Prevention Regional Association (Plant Epidemic Prevention Division)

KEY:
1. Name of crop
2. Total cultivated area
3. Diseases and damage done
4. Insect pest
5. Name of disease
6. Disease outbreak area or damage area
7. Name of insect pest
8. Disease outbreak area or damage area
9. Rice
10. Leaf blight
11. Disease outbreak area

12. [illegible] chrysographella: first period
of metamorphosis
13. Ear neck and branch blight
14. [illegible] chrysographella: second period
of metamorphosis
15. White leaf withering disease
16. Schoenobius bipunctifer, Walker: first
period of metamorphosis
17. Yellow stunt disease
18. Schoenobius bipunctifer, Walker: second
period of metamorphasis
19. Stripe withering disease
20. Schoenobius bipunctifer, Walker: third
period of metamorphosis
21. Granular bacterial nucleus disease
22. White back rice insect
23. Dot leaf withering disease
24. Delphax japonica, Horv.
25. [illegible] bacterial disease
26. [illegible] var. cincticeps
27. Stunt disease
28. Rice insect of Hydroptilidae
29. Stripe leaf withering disease
30. [illegible] assimulans, Dist.
31. [illegible] lewisi, Scott.
32. Echinocnemus bipunctains, Roel.
33. [illegible] lewisi, Scott.
34. Nymphula fluctuosalis, Zell.
35. Rice insect of Nolidae
36. Rice insect of Epiplemidae
37. Ancylolomia chrysographella, Koll.
38. Leucania unipuncta, Haw.
39. Wheat
40. Red rust wheat disease
41. Small rust barley and rye disease
42. Black rust wheat disease
43. Yellow rust wheat disease
44. Flour-like wheat disease
45. Red mildew wheat disease
46. Snow-rot wheat disease
47. Cloud-like disease
48. Sweet potato
49. White lower-leaf insect
50. Potato
51. Epidemic disease
52. Epilachna 28-maculata, Mots
53. Apple
54. Monilia disease

55. Flour-like disease
56. Black spot disease
57. Orange
58. Macula disease
59. Black spot disease
60. Pear
61. Black speckled disease
62. Black star disease
63. Grape
64. Late rot disease
65. Black pox disease
66. Peach
67. Black star disease
68. Leaf shrinking disease
69. Mulberry tree
70. Viral disease
71. Baris deplanata, Roel
72. Bud withering disease
73. Wood
74. Leaf-falling larch disease
75. Tip withering larch disease
76. Paulownia nest disease caused by Taphrina cerasi
77. White fir aphis
78. Pissodes nitidus, Roel
79. Ocneria dispar
80. Dendrolimus remota
81. Psilura monacha
82. Balaninus dentipes, Roel
83. Phyllopertha
84. Dasychira pseudoabietis, Butl
85. Mus musculinus
86. Lepus brachyurus, Temm Hare
87. Damage area.

I. Common Features of Insect Pests

A. Progress in Insecticides

Although demand for insecticides has recently drastically increased in Japan, export of domestically-produced insecticides also enjoys heavy demand; therefore, greater output of domestic insecticide is greatly required. For example, introduction of a phosphorus agent, especially a parathion agent resulted in an almost total elimination of insect pests previously difficult to prevent and eliminate.

Use of insecticides with low toxicity has been studied along with residual human toxin in plants, and domestic insecticides have been produced. Production of repellents and fungicides has been begun as a class of chemicals of lower toxicity for their natural enemies. This accomplishment could simplify the spray calendar of fruit tree insect pests through active use of the natural enemies of insect pests. Furthermore, inductive agents with biochemical effects have been produced in foreign countries. Although research on insecticides is underdeveloped even in foreign countries, some chemicals have found practical use, such as antibiotics. Recent gains in theory and industrial techniques have led to the production of one or two domestic insecticides incorporating antibiotics. Therefore, the feasibility of producing new insecticides is expected in the future, but production is still underdeveloped. Since preventive and treatment chemicals cause unknown diseases, production of new insecticides is an urgent matter. This technique will be circulated abroad in the future.

B. Mechanization of Preventive and Treatment Processing and Improvement of Large Application Machines

Mechanization has contributed to the effectiveness of prevention and elimination treatments of insect pests; however, the ordinary farm is on too small a scale to use such mechanized aids. Therefore, the spray calendar was recommended so as to take advantage of cooperative and interfarm prevention and elimination. Mechanized prevention and elimination of insects through disease outbreak predictions has proven itself. Progress in large application machines likely to simplify management process. Setbacks in this progress can be corrected by selection of cultivation management method or crop varieties suitable to large machines. For example, the cultivation method suitable for spraying SS is considered in orchard and fields. Furthermore, progress in large application machines is attributed to labor-saving sprays rather than economies in the amount of chemicals used.

The following developments are noteworthy in the effective prevention and elimination of insect pests: simultaneous insecticide spraying, fertilization, and sowing, introducing the insecticide into soil, and use of airplanes for sowing, fertilizing, afforestation, and fishing.

II. Characteristics of Diseases

A. Future Trends in Disease Outbreaks Outlined By Observation of Past Disease Variations

1. Rice

a. Prevention and treatment techniques used in rice blight disease may lead to the use of disease resistance and direct or indirect prevention and treatment methods. However, demand for higher output and high grade crops in the market has caused the cultivation of infectious crop varieties; therefore, disease outbreaks are likely to increase. However, gains in preventive and treatment techniques will gradually reduce the damage per unit field area.

b. Stripe withering disease: This disease has increased rapidly as cultivable land is being tilled fairly early in the year. The trend to early cultivation of rice affects the increase in this disease more than the usual timing of rice cultivation. Furthermore, in straight-row sowing, outbreaks of this disease may occur frequently. Excessive application of fertilizer causes frequent outbreaks of this disease.

c. White leaf withering disease: This disease frequently occurs in warm areas; however, the prevalence of more productive crop varieties has meant more frequent disease outbreaks such as in the Tohoku and Hokuriku areas. Furthering of development level of fertilizer use and early cultivation of more productive crop varieties are likely to cause greater damage to rice.

d. Types of viral disease: This disease will be caused by introducing early cultivation, over fertilization, dense cultivation, application of Oryza pasture to paddy field, and straight-row sowing. The stunt disease and yellow stunt disease transmitted by Motsch var. cincticeps occur very frequently in warm areas from southern Kanto to southern Kyushu. Stripe leaf withering disease and black stripe stunt disease transmitted by Nephotettix apicalis also occur very frequently in northern Kyushu, Chukoku, Shikoku, Tokai-Kinki, and Kanto.

e. Other diseases: Early cultivation is likely to cause yellow stunt disease and upright withering disease of seedlings in seedling beds. There is a decreasing tendency of dot leaf withering rice disease. Since

cultivated rice ripening in warm seasons is taller, outbreaks of dot leaf withering disease of rice spicules are likely to increase.

2. Field Crops

a. Red rust wheat disease is a problem. Stripe disease, viral disease, and root rot disease transmitted through soil will also pose problems since wheat and barley are major crops.

b. Viral soya bean disease is likely to increase slowly beginning from the southern Tohoku area along with increase in dense cultivation. Furthermore, soil and dense cultivation with excessive fertilizer will result in leaf disease in warm areas.

c. As to vegetable seedlings, bacterial nucleus disease is currently a problem. If vegetables are cultivated as a substitute for wheat, this disease will occur more frequently.

d. Treatment of diseases related to soil, such as upright-withering disease, root-rot disease, and leaf-rot disease is required for beet; however, this problem has not yet been solved. Increases in cultivated areas will give rise to the problem of viral disease and damage caused by continuous cultivation.

e. With potato varieties there are outbreaks of the main diseases of sweet potato and potato, but it is still unknown whether potato diseases will increase or decrease in the future.

f. Diseases caused by soil and viral diseases of fodder crops and pastures should be given close attention. Furthermore, there are new problems posed by the cultivation of perennial pasture in cultivated land presently due to latent nurturing of pathogen.

g. As for mulberry trees, disease prevention and treatment is still incompletely developed except for the trunk-withering disease. One reason is the limited application of chemicals that are harmful to silkworms as well as the fact that studies of mulberry trees and woody plants are difficult to conduct. Currently, stunt disease, a kind of viral disease, and stripe disease are major diseases of mulberry trees. There is a possibility that mechanization

of mulberry cultivation and introduction of labor-saving techniques may cause bud withering disease and red rust disease.

h. There are major problems such as the trunk withering disease of varieties of black tea and white stripe withering disease caused by soil in which tea trees are planted. In the future increase in cultivated areas of black tea varieties may cause large outbreaks of trunk withering disease.

3. Horticultural Crops

Prevention and treatment of insect pests should be considered important because the market demand for horticultural crops has resulted in frequent cultivation of highly infectious varieties of crop. These crops include peach, Japanese pear variety (20th Century pear), apple varieties (India and Delicious), and Chinese cabbage.

a. As for fruit trees, viral diseases of orange, apple, pear, peach, and cherry shorten the life of fruit trees; therefore, this disease has been pointed to as a cultivation problem relating to the upkeep cost of fruit tree orchards. In perennial crops, there are diseases caused by soil, such as stripe disease and trunk withering disease of the orange tree. This disease poses a problem relating to old cultivated land. The blast disease of the orange tree occurs frequently in late-grown oranges, which are expected to increase in future production. Greater production of apples is expected and falling leaf spot disease infects excellent varieties of apple trees. Diseases of tree seedlings such as the Western pear and peach for canning should also be given more attention as greater production of these fruits is also expected. The fact that the new cultivation of fruit trees in mulberry tree orchards results in seedling disease is a serious problem.

b. Various varieties of vegetables are affected by one or several viral diseases. Also, there are infectious diseases related to efficient and intensive soil use, such as soft-rot disease and green withering disease caused by bacteria, Fusarium capable of anaerobic life caused by mildew, Pythium, Phytophthora. Increasing damage is caused by aerobic basidomycetes. Furthermore, specific diseases frequently occur in greenhouse cultivation. If pebbly land is exploited specific diseases may occur.

c. Aster flower varieties, viral bulb diseases and *Fusarium* transmitted by soil and seedlings will be examined. Recently, viral diseases and *Fusarium* have become problems as flower disease. In this case the relationship between fruit trees and disease, as well as that between diseased trees and their natural life-span, are problems deserving study.

4. Forest Trees

There is a problem with seedling bed disease and specific tree diseases caused by *Taphrina cerasi* nests and rot diseases of forest trees. Afforestation, introduction of short-term tree cultivation, cultivation of new types of trees, and a new cultivation and fertilization method may bring unexpected results.

C. Disease Outbreaks Caused by Change in Method of Cultivation

1. Mechanization and Diseases

Although mechanization of small-size farm fields is not an important concern, large-scale mechanization does produce a few problems.

a. Effect of combine use: There is concern about whether or not the height of crop remaining to be harvested after mowing and the pathogen remaining in the plot can result in the infection of unhulled rice with black ear disease. Moreover, the amount of remaining bacterial nucleus disease can be affected by the above-mentioned conditions; this also constitutes a problem. It must be ascertained if scattering of straw and chaff on the plot after threshing causes upland rice mildew disease, stripe disease of wheat, cloud-like disease of barley varieties, and onion smut disease. The United States provides an example of mechanization causing onion smut disease and black smut rice disease.

b. The relationship between deep cultivation and mechanization: Deep cultivation is a factor for good crops, but results in slow growth in some areas. Furthermore, it is important to find out whether or not deep cultivation increases or decreases disease intensity in the growth of the above-ground portion of the crop.

2. Disease and the Change in Cultivation System and Method

a. Changes in Cultivation Period

A variety of structural changes will be added in future agriculture. The effects on disease outbreaks stemming from these changes appear unexpectedly and sensitively in paddy field and farm land. Stripe withering disease and viral disease due to early cultivation of paddy rice and root-rot disease due to early wheat sowing have already been encountered.

b. Transplanting and Straight-row Sowing

Paddy rice cultivation and field cultivation involve frequent transplanting, but a labor-saving method is likely to result from straight-row sowing in the case of paddy rice and colza. This transplanting will result in variation of disease outbreak.

One problem with straight-row sowing cultivation is aligning seedlings and plants in rows. The Mactra disease of rice seedlings may pose the first problem. Straight-row sowing in dry paddy field causes upright withering disease of seedlings, dot leaf withering disease, and rice blight disease more frequently. Straight-row sowing in wet paddy fields causes rot diseases of seedlings sometimes after sowing at low temperature. Furthermore, yellow stunt disease due to cold water, viral disease, and stripe withering disease may occur up until the middle of off-shooting period. However, rice with straight-row sowing shows poor resistance to neck blight disease.

c. Introduction of New Crops

The introduction of new crops is prevented by diseases, as in the case of beet. Unexpected diseases sometimes occur in experimental transplanting of migrated tree seedlings.

d. Deep Cultivation, Dense Cultivation, and Excessive Fertilization

Excessive fertilization causes disease frequently, as was mentioned above. The way in which fertilization of forestry land results is of concern.

3. Disease and Efficient Use of Farm Fields

a. When a common disease occurs in many crops, rotational cultivation can affect continuous cultivation. Examples are beet cultivation after frequent outbreaks of stripe withering disease due to early cultivation of rice and summer crops planted after frequent outbreaks of stripe withering disease and white silk disease.

b. Perennial pastures are likely to become nests for other crops. For example, Italian rye grass in paddy field becomes the source of outbreaks of rice stripe leaf withering disease and wheat becomes the source of outbreaks of black stripe withering disease of corn. This fact indicates possible disease outbreaks in Oryza pasture.

4. Factors Other than Agriculture

As mentioned previously, the market demand results in more cultivation of infectious crop varieties. Prevention and treatment steps are convenient in actual practice when identical crops are cultivated as the commercialization of agriculture requires.

III. Factors of Insect Pest Outbreaks

A. Factors of Outbreaks of Insect Pests on Main Crops

1. Rice

In the case of rice cultivation, prevalence of early cultivation causes the occurrence of pearl-moth. During the first and second periods of metamorphosis, the formation of two or three groups of pearl-moth begins. This tendency is more remarkable in areas with complicated cultivation method. Furthermore, early penetration of wintered rice insects into paddy fields and increases in frequency of penetration cause higher insect density. Therefore, it is necessary to develop the research on outbreak prediction methods to cope with new situations. Also, it is predicted that insects receiving no attention, such as [illegible], will appear. Progress in agriculture through large scale mechanization will change the types of insect pest outbreak and the outbreak situations. Change in the fertilization method due to the scheduled increase of production per unit area may affect the occurrence of insect pest outbreaks. For example, excessive

nitrogen fertilizer application promotes the growth of insect pests and excessive potassium fertilizer application also spreads insect pests.

2. Fruit Trees

The establishment of the outbreak prediction method and introduction of new insecticides will reduce outbreaks of insect pests, which are difficult to prevent and eliminate. Outbreaks of sucking insect pests, such as Diaspis patelliformis, Sasaki, and leaf tick, may often increase, as a result of the introduction of new insecticides and disappearance of natural enemies. Damage caused by Cryptophagus decoratus is still high; since this problem will not be easily solved. Damage caused by soil insect pests, such as Tractes divinatorius and Nematoda, can be ignored; therefore, the policy against this damage problem will be important. Furthermore, the introduction of new crop varieties is predicted to change the pattern of insect pest outbreaks.

Because of increases of forest output, afforestation, introduction of rapid growing trees and foreign tree seedlings, and fertilization on forest land have been carried out. One result was that Ocneria diapar occurred in large forests in Hokkaido. The development of such forestry cultivation will change the pattern of insect pest outbreaks.

3. Fodder Crops

The increase in fodder crops requires a policy against damage caused by Nematoda and leaf tick. With considerations of possible, frequent outbreaks of Mamestra brassicae and Botys nubilalis, research on economical prevention and elimination of insects should be started. The increase in this fodder crop may cause the penetration of insect pests into paddy fields. Consequently, the insect pest outbreak prediction method in rice fields cannot be considered without considering the density of fodder crop insect pests.

4. Special Crops

Prevention and elimination of Xyleborus praevius Blan as soya bean insect pests will become more effective by introducing new insecticides. However, prevention and elimination of Nematoda in soil will require more research for a long period. It is especially necessary to prevent

and eliminate these insects economically. As for beets, the densities of [illegible] brassicae, [illegible]rthesia chrysographella, and aphids as the insect pests on the ground surface, and [illegible] as the sub-surface insect may increase as the cultivated areas increase. [illegible]aspis patelliformis, Sasaki, and leaf tick will be disease problems for tea trees.

[illegible]. Using Natural Enemies of Insects

Future prevention and elimination of insect pests call for consideration of both insecticide and natural enemies. Since prevention and elimination of insects have depended only on insecticides, natural enemies of insects have been eliminated and the balance of nature has been destroyed; consequently frequent outbreaks of insect pests [illegible]. For example, leaf tick, Pulvinaria [illegible] Ckll, Xyleborus pracvius Blan., and shell insect appeared only in fruit trees. Furthermore, elimination of spider varieties by using insecticides caused subsequent damage by rice insect pests. Therefore, it is necessary to choose the insecticide which is not harmful to natural enemies of insects, to protect the natural enemies, and to propagate them. Decreases in production cost and increases in productivity can be obtained by decreasing the number of times chemicals are sprayed.

In foreign countries use of natural enemies of insects has decreased the density of insect pests to the extent that spraying chemicals is not necessary. However, there are few such cases in Japan; for example, Novius [illegible]us against [illegible]ytilaspis pomorum, the silver parasite insect against Pulvinaria auranti Ckll, the cotton parasite insect against the apple cotton insect, and the ruby-red parasite insect against the ruby-row insect. Thus research on natural enemies is comparatively less advanced in Japan; therefore, this research will be important in the future. For example, prevention and treatment of the [illegible]-like insect, leaf tick, and Xyleborus pracvius Blan will be much easier than in the past when insecticides played a main role of prevention and elimination. Prevention and elimination of the powdery shell insect and leaf tick of the sweet potato will be easier five years from now, and after this period a decrease in density of [illegible]borus pracvius Blan and the common shell insect is expected. In the case of pasture land, use of natural enemies is more effective than the use of insecticide.

As for natural enemies, there are parasitic bacteria in addition to insects. Some foreign countries are studying the method of spraying these parasites with insecticide through the culture of parasites; use of these parasites deserves attention in the future. As for the problem of use of natural enemies, it is necessary to consider the migration of natural enemies from foreign countries and to prepare for importation of natural enemies into Japan.

C. Improving Insect Prevention and Elimination Techniques

1. Application of Insecticides into Soil

Application of BHC and dunapon can save labor by simultaneous use of fertilizer and weeding agent. This method will prevail rapidly in the future rice cultivation. However, the relationship between the application method, soil quality, and effectiveness of insect elimination should be studied more extensively; this problem will be solved in the near future. This method aims at establishing techniques of simultaneous prevention and elimination of pearl-moth and rice insect pests, but more study is needed to attain this goal. Permeable insecticides have been used with commercial crops, such as cotton, in many foreign countries. Probably permeable insecticides with low toxicity to man will be discovered in the near future and use of this insecticide on staple crops will come soon.

2. Cultivation Without Bags

Cultivation of apple trees without bags can gain possible success in the near future and application to other fruit trees will follow. This is because research on the use and improvement of insecticides and germicides is far advanced and consumers have begun collecting information on insecticides and germicides.

3. Use of Plant Varieties that Show Resistance to Insect Pests

There are few plants which have resistence to insect pests, such as varieties of the chestnut (Ginyori) against Balaninus dentipes, Boel. However, cultivation of plant varieties with loss resistance to insect pests can decrease the number of chemical sprayings; therefore, using plant varieties with resistance to insect pests is

effective.

4. Elimination of Insecticide Resistance of Insect Pests

Continuous utilization of the same insecticide decreases the sensitivity of insect pests to insecticide. Insect pests gain resistance against a particular insecticide after its repeated application, such as pearl-moth and leaf tick against phosphorus agent. To eliminate this resistance build-up, it is necessary to investigate the alternate application of effective insecticides and to understand how resistance build-up occurs.

5. Directions in Improving Outbreak Prediction Techniques

As mentioned in 1, A, III, it is necessary to study insect outbreak types that depend on the regional cultivation method and to trace the physiological activities of the pearl-moth in order to investigate variations in pearl-moth outbreaks in early cultivation and to establish an accurate prediction method. Insect pests of fruit trees are now under experimentation; therefore, much data will be collected over the next few years. Since the same kind of fruit tree is found in different environments, it is difficult to bring together specific prediction factors through analysis. Outbreak prediction of insect pests in soil is very difficult; therefore, research on prediction should be promoted. Generally, the past outbreak prediction method has usually depended on statistical data. In the future, therefore, fundamental research on the prediction method will be required.

IV. Impacts of Insecticide Use

A. Effects of Insecticides on Society

The effectiveness of insecticides has been recognized. Market demands for insecticides has increased in agriculture, forestry, animal husbandry, and fishery. Some insecticides become toxic if they are not used correctly; as a proverb says, "medicine is just the thickness of a sheet of paper away from poison." Although market demand for insecticides was limited to successful farmers, today insecticide use prevails among farmers, such as

interfarm prevention and elimination of insects by using highly effective sprayers and spraying insecticide by helicopters. Consequently, insecticides have large effects on the national economy and people's livelihood, such as in fishery, sericulture, apiculture, natural enemies, wild birds, fowls, domestic animals, andin poisoning man. Especially in Japan there are problems of instruction in insecticide use because population density is high and small agricultural and fishery establishments are densely concentrated.

There are several ways to solve these problems: limitation of insecticide use by laws (indicating special poisons), instruction stipulated national policy (instruction in application method to prevent poison in fisheries), and use of substitute insecticides or improving insecticides (research on insecticides with low toxicity). For example, since the weeding agent PCP is toxic to fish it needs to be replaced and regulated by law. This problem will be critical since the insecticide is finding greater use.

B. Use and Production of Insecticides

In spite of unsolved problems in methods of insect prevention and elimination, many kinds of insecticides are being produced at present (insecticides include BHC emulsion and powder, 140 insecticides, and 3,000 items registered in the Ministry of Agriculture and Forestry). Since most of these insecticides are imported from Europe and the US, Japan pays considerable amounts of foreign currency every year. In 1961, imported insecticide amounted to 1.6 billion yen, imported raw material for insecticide -- 1.7 billion yen, and payment of technical assistance -- 0.3 billion yen compared to domestic production of insecticide of 30 billion yen). Since more than 50% of insecticides (55%) is applied in paddy fields, use of excellent domestic insecticides is required to cope with the cultivation method, the farmer's technical level, and scarce natural resources.

Fortunately, science and technology are progressing in Japan. Utilization of plastocygenes, preventive and treatment chemicals against blight disease, and sumithione (organo-phosphorus insecticide with low toxicity) is a bright possibility in developing domestic insecticides. Recently, comprehensive chemical industrial producers have been interested in insecticides. However,

There are many difficulties in the development of insecticides. For example, chemical products have characteristics of consumer goods and the insecticide market changes quickly. These factors require expensive experiments and research. Also, time is needed to research an insecticide thoroughly; therefore, technical scrutiny of effects on society is neglected if practical applications are urgent.

To cope with this situation, the Science Council of Japan recommended that the government establish insecticide laboratories. As a result, the Ministry of Agriculture and Forestry decided to develop new, safe insecticides. Furthermore, the agricultural technical laboratory re-organized insecticide divisions and expanded the research sections.

C. Insecticides and the Status of Agriculture

Advances and expansion in organization of insect pest outbreak prediction made it possible to prevent and eliminate insects for a sufficient period of time. The Ministry of Agriculture and Forestry and prefectures have set criteria of prevention and elimination of insect pests and for the spray calender and dedicated themselves to instruction in preventive and elimination measures. As for progress in prevention and elimination of insect pests in 1971, the Ministry of Agriculture and Forestry is playing a main role, such as spraying by helicopters, prevalence of weeding agents (weeding agent application has increased 14% compared to 50% for insecticides and 23% for germicides), and instruction in using insecticides in forests.

On the other hand, the prevalent use of insecticide has affected agricultural methods and made early cultivation possible. Although the fall of rice plant in autumn and damage caused by typhoons could be avoided, early cultivation promoted some kinds of insect pest outbreaks and requires prevention and elimination. Additionally, the movement to improve agricultural structure has recently focused on cultivation methods, but has given rise to a new threat of outbreaks of new insect pests. The decrease in the farm labor population requires high efficiency of preventive and elimination methods. This change in the agricultural situation has necessitated requirements of efficient agricultural implements and materials and new types of chemicals.

CHAPTER III

DETAILED DISCUSSION

I. DISEASES

A. History of Experimentation and Research

1. Dawn of Research (Before 1868)

Reports of scientific tests are on record even in so early a period. In these reports some researchers mentioned features of suspected plant diseases. Although in this period researchers had no knowledge of insect pests, it may be true that they confused those diseases with insect pests or they thought those diseases were caused by weather. Some researchers insisted on treating those diseases with cultivation methods. There are some reports which can be considered correct at the present time. However, dissemination of those reports was not as scientific as at present and the contents are not as scientific as that recognized at present.

2. Beginnings of Plant Pathology (1870-1893)

This period is characterized as one of the scientific introduction of plant pathology and the scientific predecessors in this country began to research general plant pathology. Study in practical prevention and treatment, however, was at a primary stage.

In spite of the rapid development of western civilization in the 1870's, school lectures were not specifically related to plant pathology. For example, in 1869 when Hilgendorf was invited to a medical school and its hospital in Tokyo, lectures on plant disease consisted of botany and

in pathology. The Sapporo Agricultural School (established in 1876) and the Komaba Agricultural School (established in 1877) began lecturing in botany (including plant diseases) in 1878 and set up a plant pathology division in 1881; however, it was abandoned in 1881.

Meanwhile, Japanese researchers gradually made progress. In 1886 Usui Kotaro of the Komaba Agricultural School and in 1889 Miyabe Kingo of the Sapporo Agricultural School dedicated themselves to research and trained students as leaders in this field.

Noteworthy features of this period were as follows:

a. Prevention and Treatment of Tree Diseases and Preservation of Timber

The beginning of surgical treatment of plant disease (1874 to 1875):

Since the cherry disease caused by <u>Taphrina cerasi</u> prevailed along the dike of the Sumida River in the Mukojima area and tree potential declined, Obuchi Ryoan, former medical officer of the Edo Regime, proceeded to cut off diseased branches.

Goals of timber preservative experiments (1879):

Since power line poles were subject to rapid decay, a preservative experiment with injection of Tannoform was conducted by Shida Rinzaburo of an engineering school with good results. This method was applied widely in the following year. In 1902, creosote injection into railroad crossties was conducted by Sugiura Sosaboru using imported machines.

Research on prevention and treatment of tree diseases was reported by Usui Kotaru on <u>Thujopsis dolabrata-Caeoma deformans</u>, <u>Gymnosporangium fusiforme</u> in 1889.

b. Research on Mulberry Tree Diseases

Ichikawa Engiro reported the importance of research on the purple stripe disease of the mulberry tree in 1891 and Sasaki Chugiro reported on the importance of the withering disease of the mulberry tree in 1892. Next year, research practice began in Aichi Prefecture in 1897 and was continued through 1904;   survey and research was conducted

by the Tokyo Sericultural Training School (refer to Report Nos. 1-7).

c. Research on Crop Diseases

Ichikawa Engiro, Tamaki Yoshizo and Miyaba Kingo identified pathogenic bacteria of cucumber rot disease as *Peronospora cubensis* in 1883, and rice mildew disease caused by bacteria was identified as Ustilago virens in 1889 and 1890.

3. Beginning of Research and Experimentation for the Disease Prevention and Treatment (1893 to 1917)

Characteristics of this period included the beginning of organization of research and experimentation on the prevention and treatment of diseases. Research was focused on classification and identification of disease agents with close attention to intensive research on crop diseases for methods of prevention and treatment that depend mainly on cultivation methods, although the direct prevention and treatment of diseases was already in effect at that time.

The Agricultural Experimentation Laboratory (A.E.L.) which has administrative authority on insect pests, is located at Nishigahara, Kita-toshima-gun, Tokyo. After establishment of the pathological division in 1899, research on preventive and treatment methods was conducted in this laboratory. This kind of laboratory was established in every prefecture at approximately the time the A.E.L. was established (refer to the following table).

Studies during this time included the following:

a. Ordinary Crops

i) Rice: Piricularia oryzae, investigated by [illegible] Kotoro in 1896, was identified by Nishikado Giichi in 1917. Meanwhile, many studies were conducted in the A.E.L. in 1893, in the Ohara Agricultural Laboratory in [illegible], and in agricultural experimental laboratories in Shimane and Nagano Prefectures in 1917. The stunt disease was identified as caused by insects by Takada and Hashimoto in Shiga Prefecture in 1895 to 1903. This study continued after this period. Moreover, the mactra bacteria disease, white leaf withering disease, small granular bacterium nucleus disease, and the dot leaf withering disease were also studied. As to seedling sterilization conducted since

Beginning Years of Experimentation and Research on the Relationship Between the Insects and Animal Pests in Prefectural Agricultural Experimental Laboratories

(From data of the <u>History of Prevention and Treatment of Crop Diseases in Japan</u>)

Name of Prefecture	Initial Year	Name of Prefecture	Initial Year
Hokkaido	1901	Mie	1922
Aomori	1903	Shiga	1895
Iwate	1922	Kyoto	1913
Miyagi	1950	Osaka	1920
Akita	1936	Hyogo	1894
Yamagata	1927	Nara	1920
Fukushima	1916	Wakayama	1914
Ibaragi	1927	Tottori	1926
Tochigi	1927	Shimane	1910
Gumma	1898	Okayama	1901
Saitama	1900	Yamaguchi	1906
Chiba	1922	Tokushima	1917
Tokyo	1909	Kagawa	1900
Kanagawa	1904	Ehime	1900
Niigata	1899	Kochi	1907
Toyama	1909	Fukuoka	1909
Ishikawa	1909	Saga	1909
Fukui	1920	Nagasaki	1900
Yamanashi	1909	Kumamoto	1919
Nagano	1904	Oita	1915
Gifu	1928	Miyasaki	1909
Shizuoka	1900	Kagoshima	1912
Aichi	1924	Okinawa	1910

[illegible], the effect of formalin and copper compound against seedling rot disease, effect of formalin against mactra seedling disease, and disease caused by <u>Piricularia oryzae</u>, and effect of organo-mercury compound were studied. At present, organo-mercury compound is generally applied for seedling sterilization.

ii) Wheat: Black tassel disease, leaf spot disease, seed sterilization, and types of black tassel disease, its prevention, and treatment were studied by

the A.E.L. in 1896 through 1912. It is well known that Sato and Yamada of the Kyoto A.E.L. studied the inoculation of corolla to prevent black tassel rye disease in 1895. In this period, many experiments and studies related to seed sterilization methods were carried out in Hokkaido, Yamanashi, Shimane, Ehime, Kagawa, and Kanagawa. Furthermore, wheat bacteria nucleus disease in Nagano, stunt disease in Kagawa, upright withering disease in Guma, and rust disease in Hokkaido were studied.

iii) Varieties of potato: Potato epidemic disease in Hokkaido, macula disease in Okayama, and black macula disease of the sweet potato were studied.

b. Special Crops

Studies on bacterial nucleus Astragalus disease in the Toyama A.E.L., tobacco upright withering disease, medicinal ginseng bacteria disease, ginger bacteria disease in A.E.L., willow black withering disease in the Gifu A.E.L., Colza bacterial nucleus disease in Fukui, flax upright withering disease in Hokkaido, saffron rot disease in Kanagawa, crust disease of cyprus tegetiformis by Kawakami Takiya, tea white spot disease in the Shizuoka A.E.L., trunk disease of the mulberry tree in Nagano, branch withering disease in A.E.L., stunt disease which was studied continuously, and Bordeaux mixture poisoning of silkworm in Guma have been carried on.

c. Fruit Trees

Studies on mushroom disease in A.E.L., apple rot disease in Iwate, monera disease in Iwate, Hokkaido and Nagano, falling leaf disease and others in Aomori, blast disease of orange trees in Wakayama, macula disease in Shizuoka and Okayama, tiger spot disease in Ehime, red star disease of pear trees in Fukui, Okayama and Hyogo, black star disease of pear trees in Niigata, flour-like disease of grape in A.E.L., and many other grape diseases in Yamanashi have been carried on.

d. Trees

Studies on pine swelling disease by Usui Kotaro in Tokyo University, cedar red withering disease in the Forest Experimental Laboratory, Taphrina ceras nest disease of paulownia by Kawakami, and other research have been carried on.

e. Vegetables and Flowers

Studies on vein damage disease of melons in Shizuoka, cucumber rot disease in the Kanagawa A.E.L., rag-borders disease in A.E.L., upright withering disease of egg-plant in Hokkaido, Niigata etc., cabbage rot disease in Niigata, horse-raddish rot disease in Shimane, sterilization of Tilis root disease in A.E.L., and other research have been carried on.

f. Other Plants

Insecticide experiments conducted in Shimane and Tokyo, and wild rat typhoid research in Shiga etc. were closely studied. With careful observation, diseases of ordinary crops are relatively limited, but diseases of special crops and horticultural plants are more frequent. As to disease, fungus diseases occur more often than bacterial diseases; viral diseases were introduced scientifically considerably later. Diseases caused by soil already appeared in the studies because of their importance. Apparently, commercial crops were studied more closely than ordinary crops; perhaps this was the trend of economic activities at that time.

3. Beginning of Prevention and Treatment according to Spray Calendars, Published by Japan Plant Pathology Association (1918-1929)

The spray calendar was introduced for the first time during this period. Practical research on prevention and treatment was developed through information exchange among researchers; fundamental studies of viral disease and its pathological and physiological aspects were begun.

At the same time as the beginning of the Japan Plant Pathology Association, its journal was published in 1918. This indicated the beginning of communication among researchers on plant disease and improvement of preventive and treatment techniques.

Furthermore, standardization and high efficiency of prevention and treatment of disease proved to be practical by study of diseases of apples and other fruits as one method of standardization; the spray calendar was drawn up and propagated at Omori in 1918. The general aim of the spray calendar was general application of efficient and rational preventive and treatment methods in different

localities according to the spray calendar. Account taken of practical cultivation when insect post prevention and treatment were studied with good results.

The spray calendar format, the first step in organizing disease prevention and treatment and in general applications of preventive and treatment methods, is very important.

As for research methods, fundamental studies began to gain importance; such studies include cultivation and isolation of pathogenic bacteria, experiments on resistance to germicides and physiological characteristics of bacteria, studies of life history of pathogenic bacteria, and intensive studies of viral diseases. Although horticultural crops were important at that time, study of these crops became the next step in developing research in later times when spraying of chemicals to control disease caused by Piricularis oryzae was studied. Experiments were assigned, consignment studies were conducted, and investigation of rice diseases was accelerated through careful examination of the achievements of previous studies.

5. Good Results of Research on Comprehensive Prevention and Treatment of Disease of Ordinary Crops (1930 to 1941)

The characteristics of this period include beginning research on comprehensive prevention and treatment of diseases of ordinary crops, ecological research, establishment of practical prevention and treatment, and organization of prevention and treatment procedures.

It had been thought impossible to prevent and treat ordinary, extensively cultivated crops directly with chemicals.

However, effectiveness of direct prevention and treatment by chemicals was proven in experiments in the 1920s. The effectiveness was due to data exchange among agricultural experimental laboratories at the prefectural and local levels. The assigned experiments and consigned research, which began in 1927, produced good results for using comprehensive preventive and treatment experiments since 1930. Results gradually proved to be effective by application in different localities. It is well known that this method was applied in 59,000 tsubo of paddy fields in Karachi and Hokkaido with good results. Subsequently this method prevailed among different prefectures.

Because of the threat of World War II at the end of this period, study of prevention and treatment of diseases of ordinary crops was extensively conducted to produce more foodstuffs. On the other hand, it is known that research on fruits and vegetables was limited due to the importance of grains.

Fundamental research gradually became popular and ecological research on diseases was begun because of the start of plot cultivation research.

5. Beginning of Prediction of Outbreaks of Diseases and Pests of Major Crops (1941 to 1951)

This period was characterized by prevention and treatment research based on prediction by development and organization of operations.

The general concept of the spray calendar and comprehensive prevention and treatment gained in popularity and was applied to many types of crops. Decreases in production of major grains due to annual variation of outbreaks of diseases and pests had to be avoided because of important demands for foodstuffs at that time. Therefore, it was required to predict the outbreak and intensity of diseases and pests, to prepare implements for disease prevention and treatment, such as insecticide sprayers, and to insist on maximum results with minimum outlay of materials and labor. It is remarkable that early prediction and discovery of pests of major staple crops was first practiced in this period due to the need to produce more staple crops. This prediction and discovery seems more remarkable when compared to mechanical prevention and treatment by using the spray calendar as the basis of prediction.

However, predictions are not 100% effective because of unexpected disease outbreaks. In spite of the requirements of raising accuracy of prediction, research on this problem was not sufficient for good results. However, this method was effectively recognized and has been applied to fruit trees since 1960. Later, this prediction method must be applied more extensively to vegetables and special crops for rational prevention and treatment.

Researchers met many difficulties in furthering their studies due to insufficient materials during and after World War II. Ecological research was developed and

overseas communication more often involved migration of crop strains in overseas surveys.

The situation on research and experimental organizations has changed. For example, branches of A.E.L. have been established since 1944 in Tohoku, Hokuriku, Tokai, Chugoku, Shikoku, and Kyushu with disease laboratory facilities. Afterwards, branches of horticultural laboratories were merged with Agricultural Technical Laboratories and eight local A.E.L. which had charge of domestic animal and the activities since 1940; these many laboratories were merged in Tohoku, Tokai, and Kyushu.

7. Good Results with New Insecticides Since 1952

In this period, new insecticides appeared and disease prevention and treatment became more efficient. Although insecticides were initially imported, domestic insecticide production began recently and its products are not inferior to imported insecticides. In any case, this period was characterized by disease prevention and treatment in agriculture, especially the application of insecticides.

Chemicals for disease prevention and treatment, mainly with Bordeaux mixture (copper compound) and lime-sulfur, have long been used. Following the war, owing to a shortage of materials for prevention and treatment of disease caused by Piricularia oryzae, application of mercury compound, fairly adequate in supply at that time, resulted in successful prevention and treatment. This opportunity was used for a more organized study of organic compounds. Therefore, prevention and treatment became more effective than the period in which copper compound was used. With this good result from research on organomercury compound, it became possible to use more fertilizer in areas of cold climate where the threat of diseases caused by Piricularia oryzae had prevented using more fertilizer. It is a well-known fact that this achievement brought about a recent increase in rice production.

Frequent outbreaks of stripe withering disease of paddy rice limited some of the cultivation methods, since early cultivation of paddy rice became more and more popular. After organoarsenic compound proved to be effective for the stripe withering rice disease, early rice cultivation and general saturated fertilizer cultivation of rice

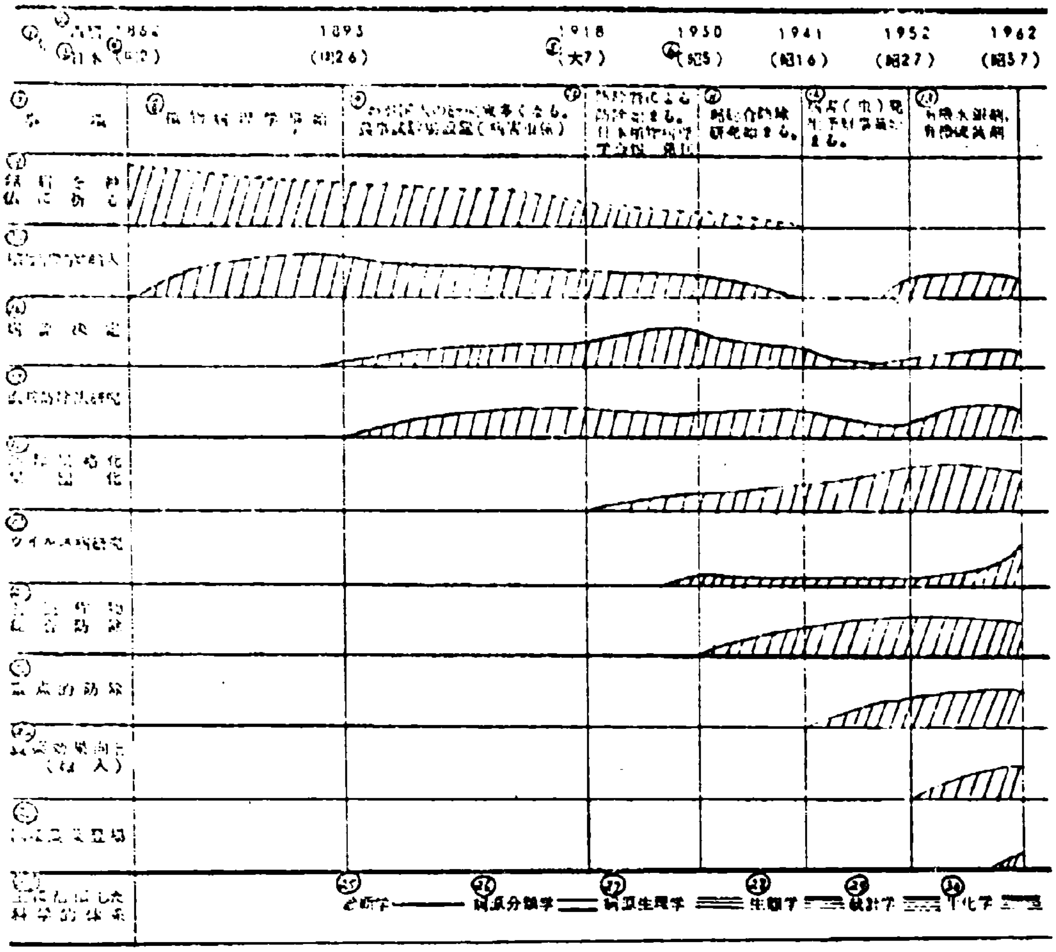
has been generally accepted. The organoarsenic compound contributed to the profits from efficient use of paddy fields.

Organic nitrogen-sulfur compound, which was imported somewhat earlier than the mercury compound, proved to be more effective in preventing diseases of vegetables than Bordeaux mixture. In addition to imported insecticides, the organic nitrogen-sulfur compound increased the effectiveness of prevention and treatment of pests and diseases in agricultural output. Recently, the appearance of antibiotic substances and other domestically manufactured insecticides on the market led to the possibility of exports to foreign countries; however, most major insecticides must be imported.

On the other hand, national organizations of research and experiments were re-organized in 1961, as shown in Chapter I, "Present Status of Experimental and Research Organizations and Systems."

NOT REPRODUCIBLE

Flow Chart for the Research Progress in Disease Prevention and Treatment



KEY: 1. Year; 2. A.D.;
3. Japan; 4. Year of Meiji;
5. Year of Taishou; 6. Year of Shouwa;
7. Items; 8. Beginning of plant pathology;

(continuation of key for Flow Chart)

9. Increase in number of studies in Japan and founding of A.E.L. (dealing with insect pests);
10. Beginning of prevention and treatment by use of spray calendar; publication of the Japan Plant Pathology Association Journal;
11. Beginning of studies on comprehensive prevention and treatment of rice diseases;
12. Beginning of prediction of outbreaks of diseases and pests;
13. Organomercury compound and organosulfur compound;
14. Prayer to Buddha for disease prevention;
15. Introduction of plant pathology from abroad;
16. Identified as the cause of disease;
17. Study on direct prevention and treatment method;
18. Standardization and collectivization of prevention and treatment;
19. Study on viral diseases;
20. Comprehensive prevention and treatment of ordinary crops;
21. Key factors of preven~ion and treatment;
22. Increase in effectiveness of imported insecticides;
23. Appearance of domestic insecticides;
24. Major branches of science used;
25. Diagnosis;
26. Classified etiology;
27. Etiophysiology;
28. Ecology;
29. Statistics;
30. Biochemistry.

B. Results of Experiments and Research

1. Studies on Plant Viral Diseases

a. Diagnosis and Identification of Plant Viral Diseases

i) Diagnosis and identification by serum reaction and viral characteristics:

Although stripe stunt wheat disease and

stunt disease of wheat varieties had been considered different viral diseases, morphological differences could not be observed with the electron microscope and similar differences could be found in serum reactions. Moreover, study of coagulation reaction by red blood corpuscles against virus revealed that this method could be applied to treat leaf spot mosaic wheat disease, stripe stunt wheat disease, stunt disease of various wheat varieties, stunt rice disease, tobacco mosaic disease, and other diseases. It was found that virus is related to raddish mosaic disease, such as cucumber mosaic disease, turnip mosaic disease, cauliflower disease, and raddish Q. The Agricultural Technical laboratory confirmed that identification method by studying serology and observing turnip mosaic virus with the electron microscope.

ii) Viral disease of potato varieties:

The A.E.L. in Hokkaido with cooperation of Hokkaido University clarified that potato diseases caused by Taphrina cerasi nests were infected by Deltocephalus striatus and that cluster stunt disease was caused by clover and Vicia unijuga, Al Br. Also, purple and yellow stunt potato diseases infected by Deltocephalus striatus, was found to be caused by the virus Callistephus chinensis, Nees by that laboratory. The Tohoku A.E.L. proposed a diagnostic method of bast stain reaction of leaf-rolling viral disease, and the stain method of the inclusion body of viruses X and Y of potato disease.

The A.E.L. found that speckled mosaic disease of sweet potato is transmitted by aphids and the disease is found among many varieties of sweet potato. Moreover, this laboratory confirmed that this virus is the same type as the internal cork virus and a different type than feathery mottle virus found in the United States. The sweet potato varieties in Japan are not subject to the internal cork virus according to this research.

iii) Viral disease of orange varieties

Foreign countries have advanced research on many viral diseases of the orange from which damage was extremely high. Although such studies have been started recently in Japan, outbreaks of several viral diseases have been discovered; among these diseases, the Hassaku orange stunt disease is the most serious. The effects of this disease (sten outtubg), lime test, and infection of orange

[illegible] revealed that this disease is caused by Tristeza or [illegible] type of virus. The Onshu orange stunt disease, which is widespread, is considered closely related to the [illegible] virus through effects of disease and lime test. The vein erosion virus is considered to exist among oranges in Japan, such as the Eureka lemon, [illegible] navel, and Miyagawa sosei (still under observation). In addition, there are many virus diseases to be studied, such as stunt disease of summer orange, falling [illegible] disease of Onshu orange, and pitting of other oranges. The Horticultural Experimental Laboratory observed the phenomena of viral disease among cowpea, Phaseolous vulgaris ([illegible] variety and topcross), and horse bean through examination of recently tested plants and juice of Onshu orange affected by stunt disease.

iv) Viral disease of chestnut

The yellow stunt disease is a disease caused by a new type of virus; the infection is initiated in grafting. Ginyory (variety of chestnut) is infectious and [illegible] at an early stage. Taisho Sosei (another variety of chestnut) in which disease occurs frequently has some kind of disease resistance. It is still not known if insects are vectors as indicated by the Horticultural Experimental Laboratory.

v) Viral diseases of tea trees

It has been discovered that yellow stunt disease of tea trees is caused by a virus.

b. Ecological Prevention and Treatment of Viral Diseases of Plants

i) Transmission of viral diseases of rice

Viral diseases of rice are four in number: stunt disease, yellow stunt disease, leaf stripe withering disease, and black stripe stunt disease. The first two disease types are transmitted by Motsch var. cincticeps and the last two by Nephotettix apicalis. Stunt disease and leaf stripe withering disease are transmitted by the respective vectors. Viral disease is transmitted through eggs. Yellow stunt disease and black stripe stunt disease afford viral transmission to other plants, but these infections do not proceed by way of eggs (Agricultural Technical Laboratory /A.T.L./ and others).

ii) Leaf stripe withering disease of rice

The A.E.L. studied the period of prevention and treatment of this disease by investigating the outbreak process of *Nephotettix apicalis*, poison residues, infective period of rice, and disease infection process. Also, this laboratory learned that damage caused by this disease is quite high in the later period of disease infection. Paddy rice in Japan is infectious and some upland and foreign rice strains have developed resistance against disease. Studying factors of disease resistance include tests of vectors and resistance against virus. Moreover, this laboratory revealed that anti-serum characteristics can be obtained through the juice of diseased leaves.

iii) Study of poison alleviation of viral diseases of plants

For the first time, the A.E.L. succeeded in culturing harmless plants by using the tissue of the growth points of diseased sweet potato and potato.

iv) Diseases of soya beans

Although there are several varieties of viral disease of soya beans in our country, only mosaic disease and stunt disease are widespread and harmful. The Tohoku A.E.L., finding varieties of soya beans that have high resistance against these diseases, analyzed hereditary resistance, and conducted prevention and treatment of these diseases. Furthermore, this laboratory observed that brown spot disease of soya bean is caused by viral disease of the above-mentioned disease group.

v) Viral diseases of vegetables

The A.E.L. in Tokyo and in Shikoku found that viral disease of raddish in warm climate can be prevented by intercropping of upland rice, and mosaic disease of tomato can be prevented to some degree by intercropping of wheat.

Study of use of radioactivity PS by using the virus of Cruciferae showed that the 'id does not inject saliva when the aphid absorbed juic om plant varieties that show disease resistance. Furthermore, the Kyushu A.E.L. assumed that there must be some specific substance in aphid saliva which is non-active against virus.

vi) Stunt disease of mulberry tree

This disease is transmitted by grafting and by [illegible]. The Sericultural Experimental Laboratory found that differences in disease resistance exist in varieties of mulberry trees, and disease outbreaks can be prevented to some degree by establishing sericultural mulberry orchards in summer and autumn.

2. Study of Bacterial Diseases of Plants

a. White Leaf Withering Disease of Rice

Outbreaks of this disease are promoted by migrated shale soil, potassium deficiency, fertilization with excessive silicates, and broken offshoots of rice (by the A.E.L. in Aichi, in Tokai-Kinki and others).

The Tokai-Kinki A.E.L. observed that this disease occurs in <u>Cuscuta chinensis</u> frequently, and bacteria of this disease wintering in <u>Cuscuta chinensis</u> infect rice -- the primary and secondary transmission sources for rice. Furthermore, the bacteria begin invasion through injured leaves. The Kyushu A.E.L. studied the winter life of bacteria and their vital processes in rice and irrigation water by using bacteriophages. This method made it possible to predict outbreaks of this disease (by the A.E.L. in Kyushu and in Hokuriku). Pathogenic bacteria can be classified in several groups according to degree of disease of various rice (A.T.L. and A.E.L. of Kyushu and Hokuriku). Moreover, classification of bacterial types is being conducted by use of bacteriophages. The multi-needle inoculation technique and its improved method devised by A.T.L., the Kyushu A. E. L., and others contributed to promoting examination of resistance against this disease. The A.T.L. studied the texture of water-repelling rice leaf tissue and the penetration of bacteria into vessels via water pores. Also, this laboratory prepared newly cultivated land through a study on the nutrition of pathogenic bacteria, and began using bacteria with disease resistance from streptomycin to study ecological characteristics of the bacteria.

b. Halo Rot Disease of Potato

Halo rot disease of potato was discovered in Hokkaido by the Hokkaido A.E.L. in 1947.

This pathogenic bacterium was found to be similar to the bacterium discovered in Germany. The A.T.L. devised an initial prevention and treatment method, such as sterilizing a pincette and cutting off the diseased portion with a knife. The laboratory also developed an examination method, such as bombardment with ultraviolet rays and the Gram staining method for the diseased potato, which is soaked in water at 47-48°C and treated with streptomycin.

c. Other Diseases

New bacterial diseases of wheat varieties were discovered and recorded by the A.T.L. and the Tokai-Kinki A.E.L.

3. Study of Cladothrix Diseases

a. Research on Types of Pathogenic Bacteria

Types of rice blight bacteria: There are types of bacteria with different pathogenic characteristics for rice in rice blight bacteria. The A.T.L. devised an examination method to observe bacteria with the cooperation of five A.E.L. at the local level for 14 types of bacteria recorded thus far. Moreover, the study on regional distribution is still underway. There are several types of bacteria with high pathogenic characteristics which infect foreign rice varieties that have disease resistance.

Types of bacteria of yellow rust disease of wheat: The A.T.L. studied infectious types of yellow rust bacteria by using variety identification as developed in our country and abroad. This study revealed that yellow rust disease bacteria of barley, which occurs in our country, is a new strain, not recorded anywhere else in the world, and is classified into four or five varieties according to paratism.

Cloud-like disease bacteria of wheat varieties: The A.T.L. found that there are types of bacteria with different pathogenic characteristics in cloud-like disease bacteria group of barley and rye in Japan.

b. Use of Disease Resistance by Disease Prevention and Treatment

Varieties of rice with disease resistance against rice blight: The Tohoku A.E.L. developed a number of methods of examination for resistance with consideration given to disease spots to give rice in Japan the rice blight disease resistance of foreign rice varieties. This laboratory then derived the hereditary form of resistance by examining effectiveness gained with this method.

Differences between varieties of coral Nematoda rot disease of rice: the Kyushu A.E.L. developed an examination method for difference of disease outbreaks between varieties of this disease. And this laboratory systematically studied rice varieties with disease resistance by examining differences in rice disease outbreaks. Furthermore, the Tokai-Kinki A.E.L. found chemotaxis of Nematoda, proliferation, and insect resistance of rice by analyzing disease resistance.

Epidemic disease of potato: Hokkaido A.E.L. studied the heredity of disease resistance of potato varieties, pangen analysis of European and American varieties of potato, structure of disease resistance, systematic examination of epidemic bacteria, and disease distribution. Furthermore, this laboratory found a substance with acidic activity in bacteria and parasitic activities related to disease resistance owing to hose metabolic activity. This laboratory developed an examination method for disease resistance and cooperated with other organizations in breeding new potato varieties.

c. Ecological Characteristics of Main Diseases

i) Rice disease

(1) Rice blight disease

Outbreak conditions in Hokkaido: the Hokkaido A.E.L. examined outbreaks in natural and artificial environments and conditions over a 30-year period. It reported important data on predicting disease outbreaks that afford understanding the relationship between coldness and rice blight disease and variation in water temperature along the Pacific coast during years of cold climate.

Outbreak probability of stem and node blight disease of rice: the Hokuriku A.E.L. learned the importance of leaf node blight disease of rice by

observing the process of penetration and injury.

Fire blight disease of rice (blast type of leaf blight disease) is likely to occur in buds and under the condition of excessive water-soluble nitrogen content in buds. Therefore, it is likely to occur in peat beds and rice nursery beds. Rice blight disease is not likely to occur with straight-row sowing in water. The Tohoku A.E.L. found that disease outbreaks of some kinds of greenhouse cultivated seedlings can be prevented to some degree by changing sowing time even though the seedling characteristics are infectious.

Although rice blight disease is believed to occur at low temperatures, it is not likely to occur at low temperatures during cold water irrigation. However, rice becomes suddenly infectious when low temperatures rise. This is considered one cause of frequent outbreaks of rice blight diseases by the A.T.L. The Chugoku A.E.L. revealed that disease resistance in plots changes with time. Cold water irrigation promotes disease outbreaks at later periods and supplementary application of nitrogen fertilizer limits disease outbreaks.

Probability, prevention, and treatment of rice blight disease of plot cultivation: In warm areas, the exospores, which scatter in the rice-tassel incubation period, become an infectious source after a certain period. The range of scattering distance is not large. Some of the rice tassel blight disease is caused by parasite with leaf withering bacteria of sesame (Shikoku A.E.L.). As for incidence of disease outbreaks and fertilization factors, phosphoric acid and potassium, which are metabolized in different pathways than nitrogen, promote outbreaks of rice blight disease for some time after fertilization. In later periods, fertilizer checks disease outbreaks (Chukoku A.E.L.). Application of calcium silicate reduces disease outbreaks. According to a study of the Shikoku A.E.L. and a Fukushima team assigned the experiment, it is desirable to apply 200 kilograms fertilizer per ten acres.

Types of leaf blight disease spots: According to the Hokuriku A.E.L., there are four types of leaf blight disease, such as brown spot type, white spot type, chronic type, and acute type. The A.T.L. and the Tohoku A.E.L. classified disease types according to quantitative constituent of diseased portions and disease spots. The A.T.L. found that infectious type disease spots occur

only in upper leaves during the infectious period. Moreover, infectious type disease spots are used as an index of selection of disease-resistant strains, ecological research on disease during plot cultivation, and disease prevention and treatment.

Disease phenomenon and physiology: Fire blight disease is the toxic consequence of rice caused by blight disease. Since the constituents of rice plant, nutrition absorption, and endoplasm characteristics are variable, metabolic activity increases rapidly throughout the leaves. The Tohoku A.E.L. found that dithiocarbamate caused effects similar to fire blight disease.

The mass production cultivation method of blight bacteria spore: The Hokuriku and the Tohoku A.E.L., and the A.T.L. developed a mass production cultivation method of blight bacteria spore through variation of nutrients, illumination, ventilation treatment, and land cultivation.

Histochemistry of disease spots in changing to brown: Tissues of rice blight disease spots change to brown. This shows the resistance of rice and was studied analytically by the A.T.L.

(2) Stripe Withering Disease

The Chukoku A.E.L. attempted to explain the outbreak process and cause of rice stripe withering disease through studies on physiological and ecological aspects of rice and pathogenic bacteria.

The Shikoku A.E.L. discovered a relationship between the initial disease outbreak and bacteria nucleus, various aspects of paddy rice, and harvest output affected by this disease.

(3) Leaf Withering Disease of Sesame

According to studies of the Tokai-Kinki A.E.L., water absorption of diseased rice roots is obstructed; therefore, the weight of dry root matter is decreased, the number of root tendrils is reduced, and the degree of root rot is increased.

(4) Granular Bacteria Nucleus Disease

Among those diseases, micrococcal disease at early stages and Micrococcus cyanous disease at later stages occur extensively. These bacteria differ from each other in mode of penetration and reaction to drugs, as reported by the Hokuriku and the Tokai-Kinki A.E.L., and Shizuoka Agricultural team assigned the experiments.

ii) Wheat Diseases

(1) Red Mildew Disease of Wheat

Ecology and aspects of disease: Wheat pollen is used mainly for multiplication of pathogenic bacteria. The Tokai-Kinki A.E.L. held that leaf disease originates in the central anther which falls onto leaves.

Differences between varieties with disease resistance and its examination: Disease resistance of wheat varieties includes resistance to infection and increase in disease resistance. Shinchujo (a wheat variety) has high and increasing resistance against infection. Iga-chikugo Oregon (a wheat variety) shows rates of increasing resistance. Norin No. 41 (a wheat variety) has low disease resistance and low increase rate. According to the Tokai-Kinki A.E.L., the inoculation method of covering plants in plots is practical as a method of examining for disease resistance.

Disease outbreaks and environment: Potassium deficiency weakens the characteristic of rising disease resistance as reported by the Tokai-Kinki A.E.L.

(2) Red Rust Disease of Wheat

The Tohoku A.E.L. found ecological types and distribution of bacteria of red rust disease in Japan and the responses of wheat varieties to this bacteria from 1952 to 1960. Furthermore, 11 varieties, five international standard varieties and six Japanese varieties, are used as standard varieties to observe ecological types of this disease in Japan. This laboratory also found that new ecological types are formed in the intermediate host Thalictrum minus L.

(3) Physiological Diseases of Wheat

The Shikoku A.E.L. proved that potassium and magnesium deficiencies cause physiological diseases,

and application of excessive potassium causes magnesium deficiency; however, application of excessive nitrogen causes potassium deficiency.

iii) Soya Bean Diseases

The Shikoku A.E.L. reported ecological outbreaks and damage caused by rust disease.

The Kyushu A.E.L. reported that sleeping disease is caused by a new bacterium Septogloeum sojae. Moreover, this laboratory developed a preventive and treatment method by investigating physiological aspects of this disease.

The A.T.L. found three new diseases among 21 caused by Cladothrix disease of soya beans in our country.

iv) Diseases of Potato Varieties

(1) Epidemic diseases of potato: The source of first outbreak is almost always diseased potato of the previous year. The outbreak period is determined by the accumulated temperature of soil and microclimate after the second disease outbreak as reported by the Hokkaido A.E.L.

(2) Black spot disease of sweet potato: Since 1953 the Tokyo A.E.L. developed a practical examination method by analyzing the disease resistance mechanism and factors related to resistance. Moreover, this laboratory clarified the relationship between disease resistance and heredity, and selection of stock vegetation for breeding disease-resistant plant varieties.

v) Diseases of Vegetables

The Kyushu A.E.L. discovered six kinds of pathogenic bacteria which cause lotus rhizome rot disease. This laboratory also developed an examination method for pathogenic bacteria of farm fields with diseased vegetables, an examination method for different degrees of disease infection in vegetable varieties, and a preventive and treatment method by using drugs.

vi) Diseases of Fruit Trees as Reported by the Horticultural Experimental Laboratory

(1) Diseases of Different Orange Varieties

Yellow spot disease: This disease was identified as *Mycosphaerella horii* Hara as a result of pathological research.

Black spot disease: The pathogenic bacteria are identified as *Phomopsis citri* Fawcett, which is *Diaporthe citri* (Fawc.) Wolf during the maturing period. The infection period of fruits and adequate temperature for spore formation on the diseased branches was clarified, and a fundamental method of prevention and determination has been found.

Macula disease: The following data was reported, including as the period of spore formation of the wintering disease spots, temperature of disease outbreaks, time of infection, degree of infection probability on young and old leaves and fruits, and disease spot types. The spore scatters in drizzly weather and does not scatter when dry.

(2) Peach Diseases

Rag-sorters disease: The pathogenic bacteria winter in tissues of diseased branches. Spores are formed on withered branches the following spring, scatter with rain drops, and penetrate into fruits by way of hairs. The oxalic acid content of the diseased branches is increased. The leaves roll up.

White rust disease: The environment of this disease with the intermediate host as *Isopyrum adoxoides* was clarified.

(3) Pear Diseases

Black spot disease: The bacteria of this disease winter within diseased spots on branches. The formation and latent periods of spores in leaves and fruits have been determined.

(4) Other Diseases

The disease first occurs at the withered branch base caused by [illegible]coccum sp.

vii) Diseases of Tea Trees as Reported by the Tea Experimental Laboratory

(1) Rag-sorters disease: The disease resistance of tea trees is related to hardness of leaves and tannin content; this phenomenon has been clarified.

(2) Reticular disease: An artificial culture of the bacteria of this disease, previously considered impossible, was successfully prepared.

viii) Diseases of Mulberry Trees as Reported by the Sericultural Experimental Laboratory

(1) Trunk withering disease: Ecological aspects of this disease causing damage in mulberry plantation in snow areas and the disease infection mechanism have been clarified.

(2) Bud withering disease: Ecological aspects of disease and the disease infection mechanism have been clarified by several studies.

(3) Flour-like disease: Although the ecological aspects of the bacteria of this disease and its life history have not been known for a long time, the main aspects have been gradually clarified for both mature and immature periods.

ix) Diseases of Grain Storage

Penicillium citreo-viride and Monase P. citreo-viride were discovered in stored rice after World War II. The study of diseased rice in the presence of imported rice revealed considerable damage caused by rice parasite of red rust disease bacteria and diseased rice due to parasites, such as Penicillium islandicum Sopp, P. [illegible] Thom., P. rugulosum Thom., and P. Tardum Thom. The following studies have been conducted: the distribution of types of bacteria, cause of disease infection, characteristics of bacteria, penetrating condition of parasite, and effect of diseased rice on animals. It has been found that if the stored rice is dried to less than 14.5%

moisture content and kept at 71% relative humidity and 10°C temperature, parasite of bacteria can be prevented. This method became the main policy in rice storage and was widely used in warehouses.

It was also known that diseased rice caused by P. citreo-viride, P. islandicum, P. citrinum, P. rugulosum, and P. tardum is harmful to the human body.

x) Diseases of Forest Trees as Reported by the Forestry Experimental Laboratory

Red withering disease of cedar: Many types of bacteria can be found in the diseased portions of the tree. Cercospora and Cryptomeriae are known as the pathogenic bacteria of this disease.

d. Prevention and Treatment of Main Diseases

i) Rice diseases

(1) Rice blight disease: Effective prevention and treatment of rice blight disease by using organomercury compound was proved as follows. In 1952, Ogawa of the Kochi A.E.L. and Hagiwara of the Hiroshima A.E.L. studied calcium silicate. The result was applied by the Chukoku and Shikoku A.E.L. and the prefectural A.E.L. in these two areas in order to experiment on effectiveness of prevention and treatment of rice blight disease by using organomercury compound (calcium silicate) and by applying experiment techniques in practice. Consequently, most of the copper compound used previously has been replaced by the mercury compound. The phenylmercury compound has comparatively high efficacy in prevention and treatment of rice blight disease among the different types of mercury compounds used. Although the phenylmercury compound is harmful for India-type imported rice, it is safe for use on Japanese rice. The Chukoku A.E.L. reported that the different function of the compound for the two above-mentioned rice varieties is due to evaporation and condensation of mercury.

As for prevention and treatment of diseases by using antibiotics, the following processes were studied. Plastocygenes, which are as effective as organomercury compound, were discovered in 1958 and in 1961 sold on the market as the world's first antibiotic for prevention and treatment of rice blast disease due to successful

Fundamental research of the A.T.L. /denotes the central A.T.L. in Tokyo/ and intermediate experiments and research of various A.E.L.

Progress in pesticide spraying methods [illegible] research on the evolution of pesticide spraying methods for rice blight disease after World War II. Among methods of spraying solutions are the horizontal [illegible] method, mist method, and extensive spraying method. Powdered chemicals are effectively applied through practical use of manual and power type powder spraying methods. Airplane spraying is becoming practical (Refer to Section IV: Airplane Spraying). Since solution is more economical generally, powdered pesticide is being replaced by solution effectively and gradually.

(2) Stripe Withering Disease

The Chukoku A.E.L. developed a simple indoor examination method by using broad bean leaves with preventive and treatment pesticides. The organoarsenic compound was found to be effective for prevention and treatment of rice stripe withering disease with the cooperation of the Shikoku A.E.L. and the related prefectural A.E.L. Later, a study of this pesticide proved that two sprayings can prevent this disease even in extensively disease infected areas.

The Chukoku A.E.L. reported that the number of pesticide spots on rice plants vary with content of iron compound.

The Hokuriku A.E.L. reported that PCP can restrain outbreaks of stripe withering disease of granular bacterial nucleus disease and reticular spot disease when used as a weeding agent in paddy fields.

(3) Leaf Withering Disease of Sesame

With this disease, P-toluene-enthrarufin-anilides of mercury, mercury iodide, and toluidine are more effective for prevention and treatment than copper compound as reported by the Tokai-Kinki A.E.L.

ii) Wheat Disease

In [illegible] prevention and treatment of red rust disease of wheat choline and

organomercury compound are effective. Choline is more effective for high quality crops. The most effective spraying period is during blossoming period as reported by the Tokai-Kinki A.E.L.

iii) Soya Bean Disease

The Shikoku A.E.L. reported that the following methods are effective for provention and treatment of soya bean rust disease: cultivation of varieties with disease resistance, delaying the sowing period, application of potassium, spraying of calcium fulfite (40 to 50 times concentration), or spraying of copper compound (4-4 type Bordeaux Mixture).

iv) Diseases of Potato Varieties and Other Plants

(1) Black spot disease of sweet potato:

The A.E.L. reported positive effects of seed sweet potato against disease, effective pesticide, and its method of application.

(2) Disease of Astragalus

The Hokuriku A.E.L. surveyed disease types and outbreaks of Astragalus in the Hokuriku area. The results proved that soaking sterilization of seed by using organomercury compound is effective for bacterial nucleus disease. Two sprayings of organomercury compound before first snow are effective.

v) Diseases of Vegetables

The Hokkaido A.E.L. reported stripe spraying of organomercury compound or choline can prevent outbreaks of smut disease in onion. Botorichis spot disease can be prevented and treated by three to eight sprayings of toluidine or 400 to 600 mannital-diazine solution applications.

The Tokyo A.E.L. reported that Ginebu is very effective for root disease of cucumber and others, and rag-sorters disease.

vi) Diseases of Fruit Trees

The Horticultural Experimental Laboratory reported that a mixture of chloromycetin and basic copper sulfate is very effective for blast disease of different types of orange trees. At Shimo-ina of Nagano Province, disease outbreaks of fruit trees were prevented by covering fruits with paper bags soaked with organomercury compound in case of black spot disease of pear. Additional application of copper compound to organomercury compound increases effectiveness. Chiba University reported that spraying organomercury compound can prevent outbreaks of leaf stunt disease; however, copper compound cannot be used because pears are damaged by the compound. It was reported by the Horticultural Experimental Laboratory that spraying of calcium sulfite compound with the addition of 0.5% PCP during winter is very effective in preventing and treating diseases of deciduous fruit trees. Organo-arsenic compound was highly effective for late rot disease of grape. As for the chemical spraying method, study on spraying using a power sprayer was applied to apple trees and became practical in our country.

vii) Disease of Tea Trees

The Tea Experimental Laboratory reported that copper compound is effective in prevention and treatment of rag-sorters disease, rice-cake disease, white-scar disease, roticular disease, and halo spot disease.

viii) Diseases of Mulberry Trees

As reported by the Sericultural Experimental Laboratory, one spraying of 1,000 to 2,000 concentrated PMF solution in mid-October is effective in the prevention and treatment of trunk withering disease.

ix) Diseases of Stored Grain

Effectiveness of sterilization with a smoking compound differs according to types of bacteria, but application of 16 grams chloropicrin and methyl bromide per cubic meter of stored grain at 25°C for three days is 100% effective. However, methyl bromide is effective on scurf rice and the elimination rate of bacteria is reduced by applying chloropicrin as reported by the Foodstuff laboratory.

x) Diseases of Forest Trees as reported by the Forestry Experimental Laboratory

(1) Red Withering Disease of Cedar

Repeated spraying of low concentrate Type 4-4 Bordeaux Mixture is effective in prevention and treatment of this disease. Copper powder compound and yellow copper sulfite powder are as effective as Bordeaux Mixture.

(2) Other Diseases

A study was made of the main diseases, such as snow rot disease of coniferous trees, leaf withering disease of pine, and upright withering disease of buds. A preventive and treatment method using pesticides was established. With the results of extensive afforestation of Larix leptolepis, tip withering disease occurs very frequently in the Hokkaido and Tohoku areas. In spite of progress in pathological and ecological research, study of the preventive and treatment method is continuing.

(3) Protection Against Rot and Insect Pest for Beech in Forests

Spraying 1.8 liters of a mixture of 5% PCP and 1-2% BHC emulsion per cubic meter of timber can prevent penetration of rot disease bacteria to some degree during the timber cutting period. Coccidium perforans can be prevented for one to three months.

e. Ecological Aspects and Prevention and Treatment of Diseases Transmitted by Soil

i) Root Rot Disease of Wheat Varieties

The Chukoku A.E.L. reported that late sowing can prevent disease outbreaks and application of lime promotes disease resistance of wheat varieties. The A.E.L. found that pathogens can be classified in many categories according to disease infection characteristics of the pathogen. This disease occurs very frequently where there is excessive fertilizer and for cultivated fields of soya bean and upland rice. Application of additional soil in wheat fields also promotes disease outbreaks. Moreover, the A.E.L. discovered that spraying ethyl mercury compound in April during the stem-erecting period is quite effective.

ii) Snow Rot Disease of Wheat Varieties as reported by the Hokkaido A.E.L.

Coldness in Hokkaido causes snow rot disease. In practice, spraying mercury compound before snowing can prevent disease outbreaks in Typhula wheat variety. Moreover, various types of disease bacteria and distribution have been understood.

iii) Yellow Stunt Disease of Raddish

This disease, which consists of vascular disease transmitted through soil, occurs in red soil frequently and in black soil less often. Raddish varieties with disease resistance are known and soil sterilization by using chloropicrin is effective in prevention and treatment as reported by the Tokai-Kinki A.E.L.

iv) Tomato Withering Disease

The Shikoku A.E.L. reported that excessive application of lime can increase disease resistance of tomato and prevent damage by reducing disease outbreaks.

f. Environmental Prevention and Treatment of Disease Transmitted through Soil

i) Mechanism of Resistance to Purple Stripe Disease

As reported by the A.T.L., the bacteria of purple stripe disease, which is very harmful and metabolizes nondecomposed organic matter in forest soil, occur in fields following cultivation. The propagation of pathogen is restrained as cultivation continues. Pectin enzym activity plays a major role in affecting resistance, and [illegible] acid, produced by pectin enzyme, promotes the action of pectin enzyme. As for sweet potato, cytochrome oxidization activity rises when parasitic activity is high. [illegible] amaroid, produced in the brown rot portion of sweet potato, can prevent bacterial growth.

ii) Prevention and Treatment of Stripe Disease of Fruit Tree as Reported by the A.T.L.

White stripe disease, occurring frequently in recent years, appears early in moist soil under conditions of good ventilation and consistent existence of a

cellulose source. Application of coarse organic matter during sowing promotes disease outbreaks. Methyl-iodide-mercury and ethylphenyl ethylaminomercury are effective for treatment of purple and white stripe diseases of fruit trees, since these chemicals are not harmful to plants and can sterilize bacteria in soil.

iii) Tea Tree Disease Transmitted by Soil

As reported by the Tea Experimental Laboratory, bacteria of white stripe disease can exist in the atmosphere, 60 cm above the ground level. Chloropicrin is found effective for sterilization of diseased soil. Moreover, chloropicrin, bapan and orthocide are effective for prevention and treatment of root rot disease of seedlings in seedling beds.

iv) Mulberry Tree Disease Transmitted by Soil

The purple stripe disease occurs more frequently in recently cultivated fields than does white stripe disease. As for soil porosity, the white stripe disease occurs more frequently in noncapillary portions and purple stripe disease occurs more frequently in the capillary portions of soil. In root rot disease, growth of hyphae bundle differ depending on different soil types. Growth of root hyphae bundle is most rapid in forest soil, less rapid in soil of mulberry orchards, and least rapid in sand river banks as reported by the Sericultural Experimental Laboratory.

C. Topics of Research and Experiments Now Underway

1. Research on Viral Plant Diseases

a. Basic Research by the A.T.L.

i) Research on classification
ii) Treatment studies

b. Research on Viral Rice Disease:

i) Research on infection by the A.T.L. and the Kyushu A.E.L.
ii) Mechanism of disease outbreak by the A.E.L.

iii) Disease resistance of rice varieties and examination methods by the A.E.L. and the Chukoku A.E.L. in 1963
iv) Serological research by the A.E.L.
v) Damage survey by the A.E.L.
vi) Research on prevention and treatment methods, consisting of:

(1) Prevention and treatment of stripe withering disease by the A.E.L. and the Shikoku A.E.L. in 1963

(2) Prevention and treatment of stunt disease by the Kyushu A.E.L.

c. Research on toxin alleviation of propagating crops for fertilization through tissue culture by the A.E.L., the Hokkaido A.E.L. and the Kyushu A.E.L. in 1963.

d. Identification and diagnosis through test plants of perennial crops:

i) Orange varieties by the Horticultural Experimental Laboratory
ii) Stunt withering disease of mulberry trees by the Sericultural Experimental Laboratory

iii) Disease of <u>Paulownia tomentosa</u> caused by <u>Taphrina corasi</u> by the Forest Experimental Laboratory

e. Research on viral diseases of wheat varieties by the A.T.L., the Chukoku A.E.L., and the Tottori A.E.L. in assigned experiments.

f. Research on viral disease of soya bean by the Tohoku A.E.L.

g. Research on viral disease of potato by the Hokkaido A.E.L.

h. Research on viral disease of sweet potato by the A.E.L.

i. Ecology and prevention and treatment of viral disease of other potato varieties by the Kyushu A.E.L.

2. Research on Bacterial Plant Diseases

a. Basic Research by the A.T.L.

i) Treatment research on bacterial plant disease,
ii) Research on plant diseases caused by pathogens and viruses, and
iii) Research on pathogens of rot diseases.

b. Research on White Leaf Withering Disease of Rice

i) Research on pathogenic characteristics of <u>Schizomycetes</u> roots by the A.T.L. and the Kyushu A.E.L.
ii) Research on pathogen wintering by the Kyushu A.E.L.
iii) Research on primary infection by the Tokai-Kinki A.E.L. and the Kyushu A.E.L.
iv) Research on pathogen activity during cultivation of rice by the Kyushu A.E.L.
v) Research on predicting disease outbreak by the Kyushu A.E.L.
vi) Research on disease outbreak and environment by the Tokai-Kinki A.E.L.
vii) Research on disease resistance of rice varieties and an examination method by the Hokuriku A.E.L.
viii) Research on disease prevention and treatment by Tokai-Kinki and the Kyushu A.E.L.

c. Research on disease prevention and treatment and ecological aspects of withering bacteria disease of paddy rice by the Kyushu A.E.L.

d. Research of prevention and treatment of perforating bacteria disease of peach by the Horticultural Experimental Laboratory.

e. Research on prevention and treatment of blast disease of summer orange by the Horticultural Experimental Laboratory.

5. Research on *Cladothrix* Disease

a. Research on Diseases at Ground Surface

i) Basic Research

(1) Research on classification of pathogenic Cladothrix by the A.T.L. and the Forest Experimental Laboratory

(2) Biochemical study of plant disease by the A.T.L. and the Forest Experimental Laboratory

ii) Research on Use of Disease Resistance for Disease Prevention and Treatment

(1) Research on pathogen types of rice blight disease by the A.T.L. and the Tohoku A.E.L.

(2) Research on rust disease of wheat varieties, including:

(a) Research of pathogenic types of yellow rust disease of wheat by the A.T.L. and

(b) Research on parasitic differentiation of red rust disease bacteria and black rust disease bacteria of wheat by the Tohoku A.E.L.

(3) Research on disease resistance of rice varieties against the main rice diseases and examination methods:

(a) Research on disease resistance of rice varieties against rice tassel blight disease and examination methods by the Hokuriku A.E.L. and the Fukushima A.E.L. by assigned experiments, and

(b) Research on an examination method for dot withering disease of rice and disease resistance by the Chukoku A.E.L.

(4) Analysis of mechanism of black spot disease resistance of various varieties of sweet potato by the A.E.L.

(5) Research on resistance against potato epidemic disease by the Hokkaido A.E.L.

(6) Research on resistance against smut disease of sweet potato by the Hokkaido A.E.L.

(7) Research on resistance against poplar rust disease by the Forest Experimental Laboratory

iii) Research on Predicting Disease Outbreak

(1) Rice disease by the Hokuriku A.E.L. and the Nagano A.E.L. in assigned experiments

(2) Fruit tree disease by the Horticultural Experimental Laboratory

iv) Research on Ecological Outbreaks of Main Diseases due to changes in Cultivation Systems and Prevention and Treatment Methods

(1) Research on ecological outbreaks of blight disease of late-cultivated rice by the Chukoku A.E.L.

(2) Research on ecological outbreaks of blight disease and stripe withering disease of rice due to straight-row sowing by the Chukoku A.E.L. and the Nagano A.E.L. in assigned experiments

(3) Research on outbreak of dot withering disease of rice due to change in time of rice cultivation and prevention and treatment methods by the Chukoku A.E.L.

(4) Examination of effectiveness of sterilizing mactra diseased rice seedlings in the early cultivation period by the Tokai-Kinki A.E.L.

(5) Examination of extent of infection due to rice mactra pathogen of unhulled rice for different cultivation periods by the Tokai-Kinki A.E.L.

v) Research on Ecological Aspects and Prevention and Treatment

(1) Research on rice blight disease:

(a) Research on blight disease of rice tassel by the Tohoku A.E.L.

(b) Research on the relationship between diseased portions and outbreak of inflammation by the Tohoku A.E.L.

(c) Research on the relationship between rice metabolism and resistance to rice blight disease by the Tohoku A.E.L.

(d) Research on diagnosis of resistance to rice blight disease by the Tohoku A.E.L.

(e) Research in warm regions on the relationship between weather and rice growth to characteristics of rice blight disease by the Chukoku A.E.L.

(f) Research on outbreak mechanism of rice blight disease in warm regions and prevention and treatment by the Shikoku A.E.L.

(g) Research on prevention and treatment method by the Nagano and the Fukushima A.E.L. in assigned experiments.

(2) Research on stripe withering disease of paddy rice by the Chukoku and the Shikoku A.E.L. and the Yamaguchi A.E.L. in assigned experiments.

(3) Research on dot withering disease of rice by the Tokai-Kinki A.E.L.

(4) Research on mactra disease of rice seedling by the Tokai-Kinki A.E.L.

(5) Research on prevention and treatment of yellow stunt withering disease of rice by the Shiga A.E.L. in assigned experiments

(6) Research on prevention and treatment of granular bacteria nucleus disease of rice by the Shizuoka A.E.L. in assigned experiments.

(7) Research on red rust disease of wheat by the Tokai-Kinki A.E.L.

(a) Research on examination methods for disease resistance of wheat varieties and mechanism of variation in disease resistance.

(b) Research on penetration into the host by pathogens and mechanism of disease outbreak.

(c) Res arch on the relationship between rainfall after spraying o. pesticides and effectiveness of spraying.

(d) Study of an economical prevention and treatment method.

(8) Research on leaf withering disease and yellow withering disease of wheat by the Tottori A.E.L. in assigned experiments.

(9) Disease of potato varieties:

(a) Prevention and treatment and ecological aspects of upright withering disease by the Hokkaido and the Kyushu A.E.L. and the Ibaragi A.E.L. in assigned experiments.

(b) Prevention and treatment and ecological aspects of rot diseases by the Hokkaido and the Tohoku A.E.L.

(c) Selection of mother roots with resistance to root diseases by the Tohoku A.E.L.

(d) Prevention and treatment and ecological aspects of brown spot disease by the Tohoku and the Kyushu A.E.L.

(10) Diseases of pasture and fodder crops for cattle:

(a) Research on disease types, scattering and damage, and fundamental experiments on prevention and treatment by the A.T.L., and the Tohoku, Hokuriku and Chukoku A.E.L.

(b) Research on ecological outbreaks of ladino-clover and prevention and treatment method by the Hokkaido and the Tohoku A.E.L.

(c) Research on outbreak of Astragalus disease and prevention and treatment by the Hokuriku A.E.L.

(11) Research on diseases of fruit trees:

(a) Experiments and research on orange varieties by the Horticultural Experimental Laboratory.

(b) Experiments and research on pear trees by the Horticultural Experimental Laboratory.

(c) Experiments and research on peach by the Horticultural Experimental Laboratory.

(d) Experiments and research on persimmon by the Horticultural Experimental Laboratory.

(e) Experiments and research on trees by the Horticultural Experimental Laboratory, Morioka Branch.

(12) Research on disease of tea trees by the Tea Experimental Laboratory

(13) Research on diseases of mulberry trees by the Sericultural Experimental Laboratory:

(a) Prevention and treatment of leaf-back flour-like disease of mulberry trees,

(b) Prevention and treatment of red coarse disease of mulberry trees.

(14) Research on grain storage disease by the Foodstuff Laboratory:

(a) Research on the respiratory rate

(b) Research on diseases of stored glucinous rice.

(c) Research on relationship between barley and red rust diseases.

(15) Research on diseases of trees by the Forest Experimental Laboratory:

Research on red withering disease of cedar, snow rot disease of conifer seedlings, tip withering disease of Larix leptoleptis, falling leaf disease of Larix leptoleptic, black spot branch withering disease of cedar, trunk withering disease of chestnut tree, etc.

b. Research on Infectious Disease Transmitted by Soil (disease of underground portion of plant)

i) Basic Research

(1) Research on Microflora of farm field soil by the Tohoku A.E.L.

(2) Research on soil micrcbes and antagonistic phenomena of plant pathogen by the A.T.L., Tohoku A.E.L. and the Ibaragi A.E.L. in assigned experiments.

(3) Diseases transmitted by soil under conditions of continuous cultivation by the Hokkaido A.E.L.

(4) Research on types of disease transmitted by soil and scattering of disease by the Hokkaido A.E.L.

(5) Research on rhizoid disease of crops by the Ibaragi A.E.L. in assigned experiments.

(6) Research on metabolism of purple stripe disease bacteria by the Forest Experimental Laboratory.

(7) Research on upright withering disease bacteria of conifer seedlings by the Forest Experimental Laboratory.

(8) Research on cobweb disease bacteria of trees.

ii) Research on types of stripe disease:

(1) Use of organic matter in stripe disease, especially white stripe disease bacteria by the A.T.L.

(2) Environmental prevention and treatment of types of stripe disease of perennial plants, such as varieties of orange trees, falling-leaf fruit trees, apple trees, tea trees, mulberry trees, and other trees (toadstool disease) by the Horticultural Experimental Laboratory, the Tea Experimental Laboratory, the Sericultural Experimental Laboratory, and the Forest Experimental Laboratory.

iii) Research on ecological aspects of disease transmitted by soil and prevention and treatment method:

(1) Root rot disease of wheat by the A.E.L. and the Ibaragi A.E.L. in assigned experiments.

(2) Stripe spot disease of wheat by the Chukoku A.E.L.

(3) Asparagus disease transmitted by soil by the Hokkaido A.E.L.

(4) Disease of bean and flax varieties transmitted by soil by the Hokkaido A.E.L.

(5) Yellow stunt disease of raddish by the Tokai-Kinki A.E.L.

(6) Tomato stunt disease by the Shikoku A.E.L.

(7) Tea disease transmitted by il by the Tea Experimental Lab atory.

(8) Colza bacteria nucleus disease by the Kagoshima A.E.L. in assigned experiments.

(9) Ecological aspects of toadstool disease of trees and prevention and treatment by the Forest Experimental Laboratory.

c. Basic Research

i) Research on the classification of pathogenic Cladothrix by the A.T.L.

ii) Biochemical research of plant disease by the A.T.L.

4. Research on Insecticides and Other Chemicals

a. Research on physiological aspects of parasites in plant disease and prevention and treatment by use of chemicals by the A.T.L.

b. Research on outbreak conditions of chemical spots of paddy rice due to blastocyzine S and the effect of chemical spots on harvest yield by the Tohoku A.E.L.

c. Research on economical prevention and treatment by use of germicides, spraying compounds, and seed sterilization compounds by the Chukoku A.E.L.

d. Research on effects of insecticides on rice diseases and side effects of chemicals by the Hokuriku A.E.L.

e. Research on prevention and treatment of rice disease and other harmful factors by the Hokuriku A.E.L.

f. Research on rationalization of prevention and treatment method of fruit tree diseases by the Horticultural Experimental Laboratory.

D. Important Subjects of Future Research and Experiment

As agriculture includes horticultural crops, pasture, and feeding crops with a demand for increased output, more studies on those crops are necessary.

Since domestic crops are competing with imported and other related crops, prevention and treatment must be utilized for greater output of these crops. The main studies on this subject are as follows:

1. Precision in Disease Outbreak Prediction, Simplification of Method, and New Exploitation in Cultivation

Although prediction of disease outbreak has been practiced effectively for rice, wheat and potato, prediction depends on experience and intuition. Consequently, fundamental studies on prediction are required. Moreover, simplification of prediction methods has been developed. If quantitative aspects of prediction and necessary treatment are applied to disease outbreak the effectiveness of prediction will increase. New cultivation and experimental prediction have begun in fruit tree plantations by the plant epidemic prevention division. As for vegetables which are hard-put to meet demand, disease outbreak prediction should be practiced before estimating demand based on stability of supply in the future. Predicting will be more important in every field in the future.

The main subjects are as follows:

a. Research on scattering of spores of blight disease bacteria;

b. Research on a rapid examination method of rice characteristics for predicting disease outbreak especially blight disease;

c. Research on a comprehensive prediction

method by using computers;

d. Use of pathogenic phage in predicting outbreak of white leaf withering disease of rice, and

e. Research on a method of predicting outbreak of fruit tree disease.

More studies are required on transmission routes of main diseases, influence of environmental conditions which cause transmission of disease, experimental methods of disease resistance of existing and new crossbred varieties, observation of crops and effectiveness of germicides.

2. Research on Viral Plant Diseases

Since viral plant diseases have not been eliminated, more studies are required as follows:

a. Prevention and treatment of vectors are effective for viral rice diseases, which are transmitted by Nephotettix apicalis and Motsch var. cincticeps at the present time. For this reason, it is necessary to study disease resistance of rice as well as ecological aspects of insect carriers and prevention and treatment.

b. Studies on infection of aphid may differ from studies on Motsch var. cincticeps because the aphid infection is due to absorption of juice.

Moreover, there are still occasions when annual crops are infected when the infectious period is early and ecological aspects of insect are suitable for the crop growth.

c. Various diseases of perennial crops: Disease progress of perennial crops is generally slow. Since the host is a perennial crop, prevention and treatment differ, such as prevention of infection with or without propagating seedlings.

d. Viral diseases of crop for fertilization: Since this class of viral disease infects the entire plant, the number of diseased plants increase rapidly. It has been possible to select a healthy plant through the cambium cultivation method. Consequently, the difficulty with this class of viral disease can be solved in the future.

e. Seedling-infecting viral disease: Although viral diseases do not infect seedling in many cases, infection on Leguminosae seedlings occasionally occurs. This problem may be solved in several ways, such as an understanding of types of virus, characteristics of disease, characteristics of infection, and culture of tissues similar to original growth tissues.

f. Soil-infecting viral diseases have been prevented to some degree by rotational cultivation and by using crop varieties with disease resistance. However, an immediate method of prevention and treatment is required.

g. Environment and outbreak of viral diseases: Outbreak of stunt disease of mulberry trees is influenced by environment. Therefore, study of this disease may lead to practical results.

h. Identification of unknown-viral diseases: There are many diseases for which it is still not known whether infection is caused by virus , or by a specific type of virus, especially in recently migrated crops, pastures, recently important crops, timber, etc.

i. Use of pathogen virus: Use of viruses has become effective for studying ecological aspects of pathogens in field cultivation due to characteristics of bacteria and proliferation of virus in bacteria.

j. Research on viral disease treatment: There is the possibility that physical and chemical treatment methods are effective for some types of viral disease. However, it may take time to apply the treatment agent.

k. To solve the above-mentioned problems successfully, the following problems should be studied and solved as soon as possible: determination, identification, proliferation, obstructing and eliminating, and disease outbreak mechanism of virus. These subjects are as follows:

i) Research on outbreak and ecological aspects of leaf stripe withering disease of rice, cultivation of varieties with disease resistance, and direct method of prevention and treatment.

ii) Research on the toxic alleviation of viruses in crops undergoing fertilization through culture

of tissue.

iii) There are Three Aspects of Research:

(1) Diagnosis and identification of viral diseases of fruit trees, (types of orange, apple and others)

(2) Determination method

(3) The research on toxin ... ...ion and proliferation through study of infection by insect vector and grafting, study of stumps, treatment, nonfertilized embryo, and cambium culture.

iv) Fundamental research on chemical and physical treatment methods.

3. Use of Disease Resistance for Prevention and Treatment of Disease

The use of plant varieties with disease resistance has been studied in plant pathological groups. The bacterial race known as rust disease bacteria of wheat was discovered in epidemic disease of potato, rice blight disease, and white leaf withering disease of rice. Therefore, in cultivating varieties of plant with disease resistance and using these varieties, methods should be studied for possible improvement. Unfortunately, fruit trees, tea trees, mulberry trees, and other forest trees require cultivation periods. However, the grafting method is effective on fruit trees and mulberry trees. Some trees have disease resistance in their scion, stump, and trunk; therefore, study of this relationship is highly interesting either in practice or theory.

Problems of diseases of pasture and fodder crops have shown up recently after extensive cultivation of these crops. Moreover, unexpected diseases occur sometimes in tree seedlings for imported afforestation. Therefore, treatment for those diseases is required. Use of disease resistance becomes an important study because chemicals are useless in this case.

Subjects of study include the following:

a. Examination of mother vegetation with

resistance against stripe withering disease of rice and study of examination method;

b. Analysis of disease resistance of rice varieties with resistance to white leaf withering disease of rice, improvement of determination method and selection of seedling of mother vegetation;

c. Research on mechanism of disease resistance of rice varieties to neck blight disease and tassel blight disease, and the determination method;

d. Research on disease resistance of varieties of rice to yellow stunt disease;

e. Determination method of disease resistance of wheat varieties to red rust disease;

f. Introduction of hereditary predisposition with resistance to epidemic disease of sweet potato in cultivation and wild growth, and

g. Research on use of disease resistance of fodder crops.

4. Drug Spraying Method and Improvement of Operation Method

The development of drug use owes a debt to the progress of sprayers to some degree. Agricultural implements and close cooperation in insecticide research and prevention and treatment techniques promoted this progress and helped in developing labor saving and rational spraying methods. Chemical spraying relied on liquid atomizing method in that period, but there are many methods of spraying liquid such as irrigation, liquid atomizing method, mist method, and injection method. Powdered agent of different grain sizes are scattered. Liquid agents and powdered agents are sprayed on plants and soil. Many agricultural implements are used, such as manual-operated implements, powered implements, and airplane. Of these implements, large machines have not been studied sufficiently. Moreover, there are unsolved problems; Some chemicals are possibly used with fertilizer and seeds to suit particular forms of liquid, powder, etc. Effective components of smoking and misting agents for field and indoor storage of agricultural products are utilized in the atmosphere. Cooperative

research among related researchers of agricultural implements and insecticides should be carried out.

The subjects of research are as follows:

a. Research on mechanization on a large scale of prevention and treatment of insect pest and effective methods of equipment use;

b. Research on contrasting forms of chemical prevention and treatment, use of powdered agents or liquid agents according to agricultural regions, seed sterilization and cultivation by using implements, and economical ways and methods for prevention and treatment;

c. Research on simultaneous prevention and treatment of disease and wild-grown grass by using weeding agent effective on germicides or adding related germicides to weeding agents;

d. Study of insecticides for relieving chemical damage, (arsonic agent for stripe withering disease of rice) or the application of insecticides for greater crop output;

e. Discovery of appropriate periods of spraying chemicals against dot withering disease of rice (including the relationship of activity of rice root);

f. Analysis of effectiveness of preventing disease outbreaks by spraying chemicals;

g. Research on the possibility of cultivation of broad wheat and progress in prevention and treatment of red mildew disease;

h. Research on the relationship between rainfall and effectiveness of chemical prevention and treatment;

i. Rational use of germicides against fruit tree diseases: as for the use of agricultural antibiotics, effectiveness of following antibiotics has been known, such as greasy phorobin against monilial disease of apple trees, antimycin against rag-sorters disease of peach trees, and chloromycetin and streptomycin against blast disease of orange varieties. Moreover, study of methods of using new antibiotics and a new method of application are required.

4. Research on prevention and treatment agents against disease related to special characteristics of tea trees.

5. Research on Invention, Improvement, and Use of Insecticides

Recently, the appearance of new insecticides promotes the possibility of developing agricultural techniques. Despite good results, some problems should be solved, such as effectiveness of prevention and treatment, effect of poison on man, animals and crops. Development of domestically-produced insecticides is a very important subject at the present time because most insecticides are imported. The ... involved regret the underdeveloped state of domestic production of insecticides and foreign aid in agricultural techniques. Recent antibiotics of excellent quality encourage these groups; however, there are still too few of these agents.

There are many diseases for which no known chemicals can be used for prevention and treatment, such as white leaf withering disease of rice, yellow stunt disease of rice, various viral diseases, tip withering disease of [illegible] lepidolepis, Gord., and many diseases transmitted by soil. Chemicals effective against those diseases are in heavy demand. Subjects of study are as follows:

a. Improvement of insecticides and invention of new insecticides with low toxicity;

b. Research in preservation of consistent bacteria resistance in plant parasites plant (development of chemicals with permeable and variable characteristics);

c. Research on prevention and treatment chemicals against white leaf withering disease of rice;

d. Research on outbreak, prevention, and treatment of diseases which occur in areas of late-ripening orange.

6. Studies on Prevention and Treatment of Disease Transmitted by Soil

Research on diseases transmitted by soil is difficult

and underdeveloped in physical and biological aspects. The importance of soil as a productive base has resulted in research on diseases transmitted by soil. The research method and theory have been promoted by progress in the related sciences, such as ecology of related plants and insects in antagonistic and interlocking microbial environments. However, since research progress is slow at present, this research and efficient use of farmland are required. Therefore, research should be extended to pathological analysis of continuous cultivation damage as well as direct prevention and treatment. The ecological aspects of disease include continuous cultivation damage, environmental prevention and treatment, prevention and treatment chemicals, and agricultural implements as research topics. Subjects of study are as follows:

a. Effect of spraying permeable chemicals on ground surface on roots and penetration of spore budding of root pathogen;

b. Study of chemicals against infectious diseases transmitted by soil;

c. Research on environmental prevention and treatment method against diseases difficult to prevent and treat (for example, root rot disease of wheat);

d. Research on chemical prevention and treatment against stripe spot disease of wheat varieties and cultivation of wheat varieties with disease resistance;

e. Research on prevention and treatment of perennial-crop disease transmitted by soil, and

f. Study on the method of promoting the effectiveness of chloropicrin.

7. Prevention, Treatment, and Tracing of Disease Outbreak due to Variation of Cultivation System through the Efficient Use of Paddy Fields

Productivity is being increased through the efficient use of paddy fields and improvement of agricultural structure. However, this efficient use of paddy fields causes variation in disease outbreaks. Therefore, study of the relationship among disease, mechanization, straight-row sowing, and introduction of fodder crops is

d. On the other hand, labor-saving techniques and labor-saving prevention and treatment methods are required because of migration of farm labor to urban areas. The same situation is found in farm fields. In other words, labor-saving mass production cultivation methods should be developed because of extensive demand forfodder crops. However, disease prevention and treatment methods related to labor-saving cultivation methods have not been sufficiently studied. The introduction of fodder crops into paddy field and orchard leads to bacterial areas for wintering latency and proliferation, and brings about various diseases in the vicinity of paddy rice and vegetable plots. Therefore, this problem should be solved as soon as possible. Subjects of study are as follows:

a. Research on variation of disease outbreaks in straight-row sowing cultivation and the causes;

b. Research on a method of preventing and treating early-stage disease in straight-row sowing cultivation;

c. Research on wintering proliferation of white leaf withering disease of rice due to efficient use of paddy fields and the relationship between the outbreak and disappearance of stripe withering disease and crops other than rice;

d. Research on occurrence and disappearance of blight disease due to change in cultivation method, shifting of cultivation period, and dry straight-row sowing field after wheat harvest, and effective nonmercury chemicals;

e. Research on dot withering disease of rice related to tassel withering and upright withering diseases of rice cultivated in late period with straight-row sowing for summer harvest, prevention, and treatment of these diseases;

f. Research on fodder crops introduced into paddy fields and their diseases.

3. Basic Research

To establish the basis of disease prevention and treatment, it is important to classify and identify

pathogenic causes. Therefore, the following studies will be carried out: identification and classification of disease pathogen for various crops, trees, and stored grains, such as viral disease, bactoria disease, and Cladothrix disease. Moreover, studies of the mechanism of main disease outbreak, prevention and treatment chemicals, pharmacology, ecology, and therapy will be conducted.

It has been mentioned that study of the characteristics of viruses and infection mechanisms is necessary. It is also necessary to conduct systematic and fundamental research to determine the pathogenic characteristics of main pathogens which occur in many places, and pathogen strains (system and groups of systems classified according to different pathogenic characteristics of pathogen, such as types of bacteria). Moreover, it is necessary to analyze the nature of disease resistance of crops to pathogens, and to conduct research on the ecological aspects and the outbreak mechanism of pathogens related to various diseases of stored grain and infectious diseases transmitted by soil; these diseases are difficult to prevent and treat.

II. HARMFUL INSECTS

a. The History of Test and Research

1. Discovery of The Method of Extermination by Oil (the pre-1868 period)

The damage of farm crops by harmful insects has long been unimaginably severe. Since the first recorded occurrence of rice insects in Harima (present Hyogo Prefecture), and seven other areas of Japan in 697, there have been numerous instances of bad crops due to the occurrence of a large number of insects. But it was not until the reign of Meiji that any full scale investigation or test was conducted. In olden times harmful insects were regarded as the punishment of irate gods; so, to counter them, prayers were offered to soothe the gods, or they were merely chased away.

However, before the test and research period began, a peasant named Irie Kichizaemon in Chikuzen (present Fukuoka Prefecture), at the time of the occurrence of a great number of rice insects in 1670, discovered, by accidently dropping whale oil on rice fields, that the rice insects died. Since then pouring oil on rice fields has been used when rice insects appeared. Thus we can trace the method of extermination of insects by oil in Japan. This is a noteworthy event. This method was applied also to rice insects in 1720 and [illegible], with good results. Since then this method has been considerably disseminated and much improved. Then it has served as one of the most reliable methods of control until the end of the Second World War. Needless to say, at the time when this oil method was discovered, even the advanced Western European countries did not have a method to control harmful insects equivalent to this.

2. Development of Control Techniques During the Early and Middle Periods of the Meiji (1869-1905)

Beginning in the Meiji era the occurrence of various harmful insects, including rice borers, was frequent. The occurrence of rice borers in the Kyushu region was particularly intense. With this as an impetus, research in this field progressed rapidly. The investigation an test on the control of three brooded rice borers by a farmer named Masuda Motohira of Fukuoka Prefecture attracted wide attention. As a result of his research and others, the control by the lighting and burning of rice stubble was recommended. The latter method was not accepted by peasants, however, because it would entail heavy labor. Consequently, in 1880 rice borer breeding centers were established at 18 places in three counties of that prefecture and efforts were made to make the peasants utilize this method. Following this, an industry model center was set up in 1887 in Fukuoka Prefecture for the study of harmful insects. This seems to be the first test and research agency for harmful insects in Japan. Through research in the early period at this center, the catching of moths and collection of eggs in rice seed beds, the disposition of rice stalks in the wintering period, and the cutting of discolored blades during the two brood period were recommended for the extermination of two brooded rice borers.

In 1881 Sasaki Tadajiro opened the first lecture series on entomoloy at Komaba Agricultural School. A similar effort was made by Matsumura Matsutoshi in 1895 at Sapporo Agricultural School. Thereafter basic research in this field was undertaken at colleges.

3. The Establishment of Government and Public Research Agencies (1896-1926)

Study at a national research agency was begun at the Kyushu Branch of the Agricultural Experiment Station at Kumamoto in 1896 by Konuki Shintaro. Also study on the insects harmful to tea plants was initiated at the Tea Experiment Station established as Nishigahara in the same year. In the following year, 1897, an occurrence of rice insects surpassing that of 1732 was reported and this made people realize again the importance of research on harmful insects. Thus, in 1898 the entomology division was established at the Agricultural Experiment Station, and the number of researchers at its Kyushu branch was increased. Thus the occurrence of harmful insects in 1897 resulted in the establishment of new agricultural experiment stations in prefectures and in the

[illegible] of the number of employees charged with the study [illegible] insects. By using a detection lamp device for the [illegible] investigation of occurrence of harmful insects, [illegible] occurrence and life cycle, including rice borers, were investigated. The preliminary investigation resulted in [illegible] a great amount of data. In 1917 Ishikawa Ryu-[illegible] produced epoch making achievements in the statistical [illegible] of preliminary investigation of occurrence by examin-[illegible] the relationship between temperature and occurrence of [illegible] rice borers, between temperature and time of moth [illegible], and between temperature and number of days of moth appearance.

As stated earlier, the test and research on harmful insects in Japan was initiated with the basic study of rice insects, reflecting the fact that Japanese agriculture was centered on the rice crop. As horticultural crops were in-troduced from foreign countries in large quantities late in the Meiji era, harmful insects were also imported and spread through nursery fruit trees, in addition to the already ex-isting insects.

For the study of insects harmful to oranges, the Re-search Center for Insects Harmful to Oranges was established under government subsidy in Shizuoka Prefecture. There a dose table, a unique application of the fumigation with hydrocyanic acid gas, was formulated. And the manufacturing of machine oil emulsion by the condensing method was invented. On the other hand during the period from the late Meiji to the Taisho, such noteworthy studies as the ecological study of imported hamrful insects, the introduction of betariya ladybird against the iseriya scale insect, and of sirubesutori kobachi against tangerine toge konajirami were made. On in-sects harmful to deciduous fruit trees, the research center on pear insects in Shizuoka Prefecture and Mr. Harukawa of Ohara Agricultural Research Center, made still another valu-able study on pear hime codling insect during the period from the late Meiji to the late Taisho.

On the study of harmful tea insects, which is closely related to the study of harmful fruit tree insects, as was stated, the study of the ecology of eight species of insects harmful to tea plants and the methods for their control, in-cluding green hime yokobai were undertaken at the Tea Experi-ment Station of the Agricultural Bureau established at Nishi-gahara in [illegible]. These studies were succeeded by the Tea Di-vision of the Shizuoka Prefectural Agricultural Experiment Station established in 1908, and then by the Tea Experiment Station of the Ministry of Agriculture

established in 1919. At the Tea Experiment Station the life cycle, habits, control of insects harmful to tea plants were studied. These studies, however, were regrettably interrupted due to the administrative curtailment of 1923.

The damage by insects to stored food in addition to to cultivated crops cannot be ignored. The study on the method of storing food was begun at the Agricultural Experiment Station in connection with the question of adjusting rice prices in 1917. Also, the study of harmful insects on stored food was begun with the establishment of the division of harmful food insects at the Plant Disease Prevention Center, but this division was abolished in 1924. Since 1925 the study of harmful food insects has been carried out by the Food Research Center.

During this period the World of Insects (1897) and Journal of Blight and Insects (1914) were published. These journals have had tremendous impact on applied entomology and the techniques for prevention and extermination.

4. From the Early Showa Period to the End of the Second World War (1926-1945)

The research on insects harmful to rice was rapidly intensified in the Showa period. Full scale research was undertaken on two brooded rice borers at the national Agricultural Experiment Stations. The Ministry of Agriculture and Forestry entrusted colleges and prefectural agricultural experiment stations with large scale testings. Many of these tests were continued upto 1940, fulfilling expectations. The study and application test of phototaxis that was entrusted to Tokyo University and Ehime Prefectural Agricultural Experiment Station was continued until 1947. As a result of them , Tokyo University attained such achievements as the finding of effective wave lengths for inviting and killing two brooded rice borers, and the relationship between the nature of the light source and phototaxis, both of which surpassed the academic level of foreign countries. In the test of trap lights, which was undertaken at the Ehime Prefectural Agricultural Experiment Station, it was discovered that the damage by two brooded rice borers could be halved by lighting blue fluorescent lamps in rice fields. Tests on rice insects were undertaken under the direction of the Ministry of Agriculture and Forestry at the Oita Prefectural Agriculture Experiment Station in 1928, and at the Department of Agriculture, Kyushu Imperial University in 1929. Through

[illegible] the life cycle process of five species of rice [illegible] the periods of various forms of growth, copulation and ovipositing; the growth and cycles at the experimental field and by the preliminary investigation lamp were clarified. The designated test on agromyza oryzae Munakata was [illegible] in 193[illegible] in Akita Prefecture. The test on rice Karabae was undertaken in 19[illegible] at the Ou Experiment Site of the Agricultural Experiment Station. Noteworthy achievements on the resistence of rice to this species were produced.

Studies of insects harmful to rice crops were carried out in many fields in the Showa period. Results were gained and various means of control were achieved. In 1940, when the occurrence of rice insects matching that of 1897 was reported in Western Japan, all available means of control were [illegible], but great damage resulted. Consequently, the conclusion was that the extermination of harmful insects could be achieved best by earlier detection and prevention. Thus the task of forecasting the occurrence of disease and harmful insects was undertaken with cooperation between national and prefectural governments. The basic research which would form the supporting pillar for this task and its applied research was about to be fully launched, but was hampered by the outbreak of the war. without proper progress it was carried on until the end of the war.

Tests and research on insects harmful to rice that were developed in many fields as test projects of the Ministry of Agriculture and Forestry in the early Showa period are highly evaluated as forming the base for the post-war detection and/or prevention and extermination methods. On the other end, the need to establish proper means for prevention and extermination of insects harmful to dry field crops was felt during the war because of the urgent need for increased food production. Up to that time only research on the main harmful insects had been carried out.

Of the insects hamaful to deciduous fruit trees, the introduction of natural enemies of apple watamushi on apple trees, and the study of the utilization of immunized grape [illegible] were carried out effectively. Considerable achievements had been made in the study of the peach codling moth, but in the 1935-1945 decade, priority was placed on the study of insects harmful to main food crops, due to the progress of the war, and research on harmful insects on fruit trees was interrupted. Nevertheless, some techniques for prevention and extermination were found through the efforts of [illegible] cultivators.

In addition to the foregoing, the considerable damage to mulberry and forest trees by harmful insects cannot be ignored. Of the insects harmful to forest trees, the damage by gold bugs to nursery trees under intensive agricultural cultivation, is severe. Thus priority was given to preventive and extermination tests. During this period the investigation of pine boring insects that appear following the damage by typhoons and on the pine caterpillar were made. The basic research for the prevention and extermination, and the research on rational methods of prevention and extormination wasn't undertaken until the end of the war.

5. The Post-war Period (since 1946)

As was already mentioned, research on harmful insects was, of necessity, slackened due to the outbreak of the Second World War. For a while immediately after the war, research in this field was stymied due to the confusion following the defeat. But beginning in 1946 and 1947, research on the prevention and extermination of harmful insects made great proggress thanks to the gradual ordering of the research facilities at various research agencies and to the introduction of organic synthetic insecticides from overseas. Especially on the research on insects harmful to rice, as is well known, reform was brought about by the progress made in research on the detection of the occurrence of harmful insects and the establishment of application methods of new insecticides.

Even though remarkable progress was made in the postwar period on the research into the prevention and extermination of harmful insects, new problems have come up as will be stated later. Moreover, there are untouched areas of research on harmful insects, namely: dry field insects, including these on animal fodder crops, horticultural crops, and timber. Therefore, a further intensification in the research system is required.

6. A History of The Research on Harmful Nematodes

The organized basic research on harmful nematodes parasitic on plants in Japan was initiated by the Zoological section (Professor Kaburagi Edao) of the Department of Agriculture, Tokyo University, in the early part of the Showa (1928-1935). By that time, the test system and research on nematodes was well established in England, Holland, and Germany. In the United States energetic research had been conducted

[illegible] the establishment of the nematology research agency of [illegible] Department of Agriculture in 1907. Even this sole example of research at Tokyo University almost disappeared after 1935. [illegible] the much needed prevention and extermination of [illegible] in farming has been long neglected. Only in about [illegible] did the Ministry of Agriculture and Forestry begin tests on the prevention and extermination of Meloidogyne on sweet potatoes, at the designated test site in Chiba Prefecture. [illegible], at the Hokkaido Agricultural Experiment Station; test and research on the prevention and extermination of Hetero-[illegible] of soy beans had developed uniquely since the latter part of the Taisho.

In 1955, in the post-war period, a disease that caused [illegible] diseased spots on the potatoes produced in Nagasaki Prefecture occurred. From the tissue of these diseased spots, a species of Pratylenchus spp., which is the pathogen, was [illegible]. As a result of this, a test site was designated for the study of the prevention and extermination of potato [illegible] and diseases. It was established in 1957 in Nagasaki Prefecture for the main purpose of working on nematode prevention and extermination methods. This served as an impetus in attracting general attention to nematodes. Thereafter, a desire for the development of dry field crops was fermented in our agricultural policy, and research on nematodes suddenly received the green light. Thus, the Ministry of Agriculture and Forestry established the nematology research section at the Agricultural Technology Research Center in 1958 and undertook basic tests and research on the classification and control of harmful nematodes. The Ministry also, in 1959, began the diagnosis of soil nematodes in dry field crops and a pilot test for prevention and extermination; since then it has promoted this test on a nation-wide scale. With the recent progress in the development of fruit trees and the policy for the development of livestock, the investigation of harmful nematodes in forest trees and in pastures (fodder crops) has been carried out. Thus, the need for the prevention and extermination of nematodes has become clear, and there has been intensified nematological research.

B. The Results of Test and Research

1. The Detection of Harmful Insects

In the detection of the first appearance of the moths of two brooded rice borers, the existence of a high negative

correlation between the temperature during the March-June period and the time of appearance, based on the data for investigation of fluctuations of moth appearances, was recognized in many areas. The combination of the detection formula by the recurrent equation between temperature and the time of moth appearance was formulated by several researchers in about 1943. But in recent years, the occurrence of this species has undergone remarkable fluctuation due to the dissemination of early planting or early cultivation. Therefore, a detection method to respond to such a situation was required. Consequently, the method of estimating the time of moth appearance by heating wintering larvae to 25°C in March and then by investigating their maturity by the measurement of the period before pupation, that is, experimental detection by this "heat adding method", was established by the Agricultural Technology Research Center and the Saitama Prefectural Agricultural Experiment Station.

The method of detection of the second appearance of two brooded rice borers, moths, the pupation rate method of detecting peak moth appearance by finding 50% pupated days by investigating growth of larvae in withered stalks in the latter part of the first generation larvae period, and the "cyte-method" for estimating the days of emergence by measuring spermatocyte diameter after placing the male testis of first generation larva of 4-5 instars, were established by cooperation between the Agricultural Technology Research Center and the Saitama Prefectural Agricultural Experiment Station. The method of detecting the first occurrence of two brooded rice borers; an experimental method for finding the volume of the first moth appearance after determining the death rate due to parasitic bacteria and parasitic bees and due to physiological weakness by applying heat to larvae of the wintering generation and then taking this death rate into consideration when figuring the volume of second generation occurrence in the preceding year, has been proposed.

The method of detecting the appearance of two brooded rice borer moths for the second time; the method of estimating the volume of second generation occurrence on the basis of conditions of first generation larvae through the periodic investigation of broken up rice stalks has been proposed.

No adequate method for detection of the occurrence of Cicadula sexnotata, or yokobai has been established, due to the inadequate basic research on their physiology and ecology, frequency of occurrence, and inadequate understanding of their outdoor ecology. In recent years, however, the method of

[illegible] from similar species, the growth process of fetus [illegible] and the wintering of Sogata furcifera Horvath and [illegible] lugens Stal have been gradually clarified. Also, [illegible] investigation method, at both the experimental site and [illegible], by utilizing a specially devised and tested collector [illegible] stick trap has been established. Thus, achievements indicate a bright future in this field.

2. Crop Cultivation Systems and the Occurrence of Harmful Insects

In the customary cultivation of rice in warm regions, only a limited nursery bed area exists for wintering of harmful insects. But when early cultivation is introduced, the occurrence of harmful insects is generally increased by normal early planting cultivation.

In the case of the early cultivation of wet rice, it has been discovered that two brooded rice borers and tsumaguro [illegible] show a remarkable occurrence, while Sogata furicifera Horvath, Himetobi unkah, nilaparvata lugens Stal, Epiacanthus [illegible] Motschulsky, rice aomushi(sic), rice tsutomushi [illegible] oryzae Munakata, rice karabae, Lagynotomus assimalans [illegible], black rice scale insect, Leptocorisa varicornis Fabricius, and plant lice show a considerable occurrence, and that three brooded rice borer and Sesamia inferens Walker occur locally.

In the case of normal wet rice cultivation in regions where early cultivation has been introduced, the first generation two brooded rice borers show remarkable multiplication tendencies, with early wet rice fields as the most suitable places for growth. Because of this, an increase in the damage by the second generation results. An increase in the core-withering of stalks, due to damage caused by second generation, three brooded rice borers frequently occurs in early wet rice. This along with occurrence of white heads due to damage by the third generation have been found to be notable changes. In some areas it has been noted that there is a tendency for increased occurrence of Minami Ao Kamemushi which had not shown up much due to the lack of fodder crops suitable for the second generation. Under these circumstances, early wet rice fields became breeding grounds for the second generation.

3. The Ecology of Botanical Virus Carrying Insects

It has been found that the Cicadella ferruginea Fabricus, which carries the withering disease and yellow withering disease of rice plants, awakens from hibernation in February, becomes adult in March, and goes through five generations a year in Western Japan. The number of days of growth of the larvae of this species, containing this rice virus pathogen, is delayed by about a day, as compared with a healthy one. The life of such an adult is short and the number of its ovipositions is 60% less than a healthy insect. In a group with a high rice virus pathogen rate, the time from hatching to the time when it acquires the capacity to infect rice is short and the death rate of larvae is high.

It has been found, on the ecology of Formosa Cicadella ferruginea Fabricus, that the number of days until adult is [illegible], and that before oviposition is 6-9 days; this is not much different than Cicadella ferruginea Fabricus, except that the period of oviposition is slightly longer. The minimum temperature for its growth is 14.7°C, somewhat higher than the 13°C for Cicadella ferruginea Fabricus.

The Agricultural Technology Research Center and the Shikoku Agricultural Experiment Station have clarified that Taiwan Cicadella ferruginea Fabricus awakens from hibernation in late December, and emerges earlier than Cicadella ferruginea Fabricus in the spring. After emerging it moves to Gramineae grasses and the early planting nursery beds to multiply. In the period from mid-June to late August, groups of individual insects that float in the air appear. The peak period of the flight of the second generation adults to the main rice fields differs according to planting time and takes place during the period when the nitrogen content in the rice plant is highest just before the peak stooling period.

4. Insects Harmful to Meadow Grasses and Fodder Crops

There are about 200 species of insects and over 20 species of nematodes harmful to meadow grasses. It has been found that among these, Hasumon yoto, sesamia inferens walker, Cirphis unipuncta Haworth, Barathra brassicae Linne, Kofusa-[illegible] moths and yellow slugs are important ones.

5. Utilization of Insect-proof Varieties

(1) Rice Plants

Norin No 8 and Aichi Asahi are subject to the ovipositing of two brooded rice borers, but the decrease in yield due to the insects is markedly small. (Tokai and Kinki Agricultural Experiment Stations.)

On the resistance of rice plants to two brooded rice borers, it has been observed that the damage to wet rice plants in the Shuraku wet rice region is intense. Yamanashi University has noted, however, that the quantity of effective silicic acid contained in the wet field soil and the irrigation water of this area is small and the quantity of silicic acid contained in rice plants raised in this area is also small. Thus, it was clarified that when silicic acid is applied to such soil, the damage caused by this species can be greatly decreased.

Tests on Inekarabae were undertaken early at the Ou area test site of the Agricultural Experiment Station. As a result many insect-proof strains were detected, and it was recognized that in the strongly insect-proof strains the death rate of larvae was high. Since then, the examination of many new insect-proof strains have been made at the Akama test site (designated test) of the Shimane Prefectural Agricultural Experiment Station, Tohoku Agricultural Experiment Station, Hokuriku Agricultural Experiment Station, and Chugoku Agricultural Experiment Station. Thus, the simple method of testing insect-proof strains that suit each area has been established. Moreover, the heredity pattern of insect-proofness has been clarified.

(2) Chestnuts

Tests made at the Okayama Agricultural Experiment Station and other experiment agencies found that Kuri tamabachi cannot complete its growth in such chestnut strains as Ginyose, Kishine, and Otsuso. Therefore, these strains have been confirmed as absolutely insect-proof.

(3) Soy-beans

Tests made at the Hokkaido Agricultural Experiment Station and Hokkaido University found that the ovipositing of grapholitha glycinivorella is not

possible in soybean strains having extremely few hairs on pods in those with extremely short hairs.

6. The Utilization of Natural Enemies

The utilization of rubiakayadori kobachi against rubiro mushi on citrus trees has been proven successfully after recent experimentation by Professor Yasumatsu Kyozo. The use of this bee has also been successful in the release test against scale insects on tea plants at the Test Experiment Station. Also the utilization of traditional parasitic bees against kuritamabachi and the release of sugitama yadorihi kobachi have been successfully carried out.

7. The Effective Application of Insecticides

In the effectiveness and economy of insecticides against harmful insects, the spraying of liquid insecticides is sometimes advantageous. Recently, the effective spraying of liquid insecticides has been tested. Also, the prevention and extermination of above ground harmful insects by the concurrent application of insecticides and fertilizers or herbicides has been examined. This method not only is labor-saving but also makes it possible to eliminate the unfavorable aspect of insecticide spraying, exterminating natural enemies. Thus, this method merits attention.

The Kyushu Agricultural Experiment Station has, since 1954, continuously tested the prevention and extermination of insects harmful to the above ground portions of crops by applying insecticides to the soil. The Chugoku Agricultural Experiment Station has, since 1956, continuously experiment with several varieties of insecticides. It has been found that when about three times as much BHC as is applied on the surface is mixed into the ground during alternate ploughing, two brooded rice borers that encroach on early rice can be killed; and that when denapon is added to the BHC application, two brooded rice borers, as well as cicadella ferruginea Fabricius are exterminated effectively, and the rice viruses carried by cacadella ferruginea Barbricus can be prevented. Dropping BHC grains on the surface of the soil several days after transplanting or manual scattering of finely granulated BHC on the surface of the water, have become practical. These methods have been established through the cooperation of the national or prefectural agricultural experiment stations and farm chemical companies. They are

advantageous in that they require a smaller quantity of chemicals.

5. The Prevention and Extermination of Main Harmful Insects by Insecticides

(a) Insects harmful to rice plants

Since 1947 the effectiveness of BHC against two brooded rice borers has been confirmed by the agricultural experiment stations at Shizuoka and Kagawa prefectures and in the Tokai Kinki and Shikoku areas. Thereafter the forms of spraying, density, timing, and method of spraying were tested, and the proper method for its use was established in about 1950. At the same time as the great occurrence of these insects in 1951, a test sample of parathion emulsion (Folidol E 605) was imported and, soon after, it was tested at the Shikoku Agricultural Experiment Station. It was confirmed that by spraying it on rice stalks and blades the larvae in the stalk were all exterminated. Thereafter the method for its use was established and the early growing of wet field rice was further facilitated. It was found that EPN was almost as effective as parathion and such low-poison organic phosphorous compounds as blait and smithion were almost equally effective.

Beginning in about 1948 the effectiveness of DDT and BHC against three brooded rice borers was tested. In 1950 the Kochi Prefectural Agricultural Experiment Station recognized the practical use of 1% BHC powder spraying against the encroachment of third generation larvae. In 1951 its effectiveness against second generation larvae was confirmed by the Shikoku Agricultural Experiment Station and the Kagawa Agricultural Experiment Station. In 1951, at the Asaki test site of the Wakayama Agricultural Experiment Station, it was found that the spraying of parathion is effective also in preventing the occurrence of white heads. It was also discovered there that the spraying of DDT during the hatching of first generation larvae is effective in preventing the encroachment of larvae already hatched. In this way occurrence of this species can be markedly suppressed thereafter. Thus, this method has been widely practiced in areas where three brooded rice borers occur, in Wakayama Prefecture and elsewhere.

DDT, BHC, NAC, malathon and parathion have been used as preventive and exterminative agents against rice insects, and all but BHC against cicadella ferruginea Fabricus.

In 1949 it was discovered that ineküro kamemushi can be exterminated by spraying 3% BHC powder during the early larva period, and lagynotomus assimulans Distant and leptocroisa varicornis Fabricius can be exterminated by 1% BHC powder. In 1952 the agricultural experiment stations at Ishikawa, Fukui, Kochi and Kyushu, confirmed the effectiveness of parathion against the wintering larvae and larvae of young instars of black rice scale insects which are strongly resistant to BHC. Recently, it has been found that both bidit and parathion can kill black rice scale insects and minami scale insects.

The practical effectiveness of EPN and derudorin against inekarabae was confirmed in 1948 and 1949. Thus a new hope was seen in the prevention and extermination of this species which had hitherto been regarded as extremely difficult. Moreover, in recent years such low-poison chemicals as dimetet, pesutan and bidit have become available for the prevention and extermination of this insect.

The effectiveness of BHC and parathion against ineha moguribae and inehimcha moguribae has been confirmed.

(2) Insects Harmful to Barley, Wheat and other Cereals

The effectiveness of arudorin and butakuroru for the prevention and extermination of wireworms has been confirmed.

The effectiveness and use of DDT and BHC against tipula aino Alexander were tested in 1949 at the agricultural experiment stations at Kanto-Tozan, Shimane, Tottori, Yamaguchi, and Toyama. As a result it was found that it was best to sow seeds with DDT applied to them. Later, it was also found effective to spray parathion after the occurrence of this insect.

It was found that the spraying of DDT, BHC, and parathion two or three times during and after the peak period of ovipositing was effective against pyrausta nubilalis Huebner.

The effectiveness of parathion against daizusaya tamabae was recognized, and this was the first ray of hope in the prevention and extermination of this species. It has been recently found that bidit is particularly effective against it.

The effectiveness of BHC and parathion against shiro [illegible] madara meiga and the special effectiveness of endorin have been proved.

[illegible] and endorin are effective against daizu kukimoguri [illegible] and their use has been tested at the Kagoshima Agricultural Experiment Station.

(4) Insects Harmful to Other Vegetables

The Tokyo Metropolitan Agricultural Experiment Station has proved the effectiveness of DDT for the prevention and extermination of ocbia undalis Fabricius, which is harmful to the core of the bud of garden radish and Chinese cabbage. [illegible] and malathon are effective for the extermination of the [illegible] which frequently occurs on the genus of grapes. It has been found that for the extermination of aulacophora fermor[illegible], harmful to melons and cucumbers, the spraying and [illegible] of derudorin and arudorin against the wintering [illegible] underground larvae are effective. DDT is quite effective against phyllotreta striolata Fabricius, when it is sprinkled or its emulsion or powder is sprayed after germination. Against nightwalkers and green caterpillars, the spraying of DDT, endorin, and dipterex emulsion during the larva stage is effective.

(5) Insects Harmful to Tea Plants

For the prevention and extermination of kanzawa ha dani on tea plants, lime sulphur compound has long been used, but [illegible] has replaced it. The effectiveness of DDVP, EPN, and parathion against adoxophyes privatana Walker and calop[illegible] theivora Walsingham has been proved. At present DDVP and EPN are used.

(6) Insects Harmful to Fruit Trees

In the prevention and extermination of insects harmful to citrus trees, the spraying of lime sulphur with sulphuric [illegible] is effective in the prevention of the occurrence of the larvae of prontaspis yanonenis Kuwana. It has been proved that [illegible] spraying [illegible] parathion, EPN, dimetoet, pestan is effective against prontaspis yanonenis Kuwana and ceroplas[illegible] floridensis Comstock.

The spraying of DDT is effective against the encroachment of the codling moth to harmful deciduous trees, in places where their occurrence is not too severe. Recently, it has been proved that low-poison bidit is as effective as parathion against it. Against leaf folders on deciduous fruit trees DDT, BHC, endorin, parathion, diazinon and denapon, in addition to lead arsenate has been proven effective.

(7) Insects Harmful to Mulberries and Fiber Plants

Spraying lime-sulphur compound, calcium cynamide solution, and machine oil emulsion during winter and after the cutting of mulberries in spring and summer is effective against kuwa kaigara. The proper time, kinds, and density of such spraying have been clarified.

Against kuwa kaigara, such organic sulphuric compounds as TEPP, DDVP, dipterex are effective and are used even during the raising of silkworms. BHC and parathion also are especially effective, but they seem to leave after-effects and thus are not too practical. Against himezo mushi, BHC, DDT, and both liquid and powdered pyrethrum are effective and application methods have been established. Against shintome tamabae DHC, DDT, DDVP, and diptelex are effective. They can be used either on the surface of soil before occurrence and or can be sprayed after germination. The concurrent use of both methods is more effective.

Chlorpicrine and methylbromide are effective as fumigation against katsuobushi mushi, harmful to cocoons and raw silk.

(8) Insects Harmful to Forest Trees

The insects most harmful to the nursery stock of forest trees are the larvae of May bettles. For their control, powdered BHC may be sprayed all over the nursery bed and then may be mixed with soil at about the 10 cm depth. The control of sabihyotanzo mushi is possiblewith such soil insecticides as arudorin and heptachlor.

For the control of mimela costata Hope, harmful to the roots of the larch, powdered BHC or arudorin is mixed into the soil in the hole where it is planted. Matsuha kare, matsuaoki habachi, matsuno midori habachi can be controlled during early stages by powdered BHC and BHC smoke.

[illegible] dispar Linne, DDT and BHC are effective.

Against Matsumo tamabae and Sugi tamabae that form [illegible] parasitic to pine trees and cedars, the spraying of powdered BHC on the ground just prior to emergence is effective.

Against boring insects, BHC oil is effective. For the prevention of the encroachment of boring insects in cut timber, 0.5%-1% emulsion of BHC or derudorin is effective.

(5) Harmful Birds and Animals

The chemical control of wild mice is the most advanced in harmful birds and animals. Recently, strongly poisonous chemicals with less secondary damage have been used; zinc sulphide is a typical one.

For the control of wild mice a labor-saving method is recommendable, in view of the recent labor shortage. Because of this, the spraying of chemicals should be done by helicopter. For practical use, therefore, research has been made on spraying impelements, the types of chemicals to be used, and the quantity of spraying. Since the fall of 1959 it has become practical with considerable success.

9. The Control of Harmful Insects by the Spraying of Insecticides from the Air

At present, the spraying of insecticides from helicopters is effective in the control of young, two brooded rice borer instars, cicadula senotata and yokobai that carry rice plant viruses, psychostrophia melanargia Butler on apple trees, and several species of insects harmful to forest trees.

10. Harmful Nematodes

(1) Classification

In 1957 the number of species of harmful nematodes in Japan amounted to 8 genera and 12 species, including meloidogyne, aphlenchoides, and heterodera. But, at of the end of 19[illegible], 21 genera and 68 species were confirmed. Negusare nematodes and external parasitic nematodes, the largest proportion, can be diagnosed only by careful and close examination.

Beginning in 1959, Hirshmania oryzae, which inhabits rice field soil and is parasitic on the inside tissue of rice roots, has been continuously sighted in Yamagata, Fukushima, Tokyo, Saitama, Chiba, Shizuoka, Nara, Hyogo, Hiroshima, and Yamaguchi Prefectures.

(2) Physiology and Ecology

In the case of meloidogyne spp., the larva first infiltrates into the tissues of the roots of the host plant, and then by a certain kind of matter emitted from the insect, forms large cells in the plant. Heterodera spp. winters in this cyst, and upon hatching the larva becomes parasitic on the root tissues of the host plant. The larva becomes adult after three ecdyses. The adult female gradually expands and eggs are discharged into the egg sac formed at the end of the body. The exterior skin of the insect becomes fat, its color changes to brown and becomes a cyst to contain eggs. The cyst is apt to fall from the root and remain in soil. It is strongly resistent to low temperature and dryness. Pratylenchus spp. destroys and goes into the tissues of the root, and causes the necrosis of tissues. Thus the root shows symptoms of root-rotting and the crop does not grow well.

The external parasitic nematode destroys the tissue cells by its long mouth needle, from the exterior of the root tissues. Harmful matter is emitted and a pathological condition of the root results.

(3) Control

For control of crop damage from nematodes, avoidance of consecutive cultivation of the same crop and rotation with uncontaminated crops are stressed. The rotation of crops is still fundamental to the control of nematodes even though insecticides effective against them are available. The wider the host range of nematodes is, the more difficult the rotation with uncontaminated crops becomes.
In this case the resistence to nematodes differs with kind of crop. Therefore, effectiveness in rotation of crops of different kinds can be expected. The cause of the problem arising from consecutive planting of the same crops has not been clarified. There have been instances where nematodes are the main cause and disinfecting the soil has proved effective

Avoiding nematodes by introducing resistent crops is an effective cultivation technique. Against soybean heterodera, efforts have been made toward clarification of the function of crop resistence and the growth of resistent crops.

The so-called soil smoking types form the main body of those used in the chemical control of harmful nematodes. D-D and EDB, which became available after the war, were used only with a manual injector at the time of their import. They were used in the warm vegetable growing areas, in warm areas near large cities and in the special high-yield crop zones. In recent years, however, the development of application implements together with the testing of and research on applications, have been actively carried out and their use has become widely practical.

It has been proved that the differences of soil character and soil temperature are important in effective chemical application.

Points to be watched in the application of chemicals include : side effects of chemicals on crops, dike care for reduction of the quantity of chemicals, or the control effectiveness in the care of plant holes, the chemical treatment between dikes, and the condition of soil and effectiveness before chemical treatment. Test and research on their practical use have been undertaken.

II. Basic Problems

The basic research on the control of harmful insects and on their detection did not become active until the early years of the Showa (1926 tothe present). The comprehensive research on rice borers, which was carried out on a nation-wide scale, played a large role in technical developments thereafter.

The present tasks in basic research are widely varied. In the physiological field, the clarification of insect growth physiology and metabolism, forms the principal axis; collective ecology and individual ecology act as lage props. Rapid development in research on the functional structure of farm chemicals has expanded in recent years.

Research on the damage structure of crops and damage investigation is about to be given impetus with new techniques.

The establishment of a biological examination of the effects of farm chemicals has been requested from many fields. The appearance of insects resistent to farm chemicals has given new momentum to this area of study.

(1) Classification

1) Identification

A program of identification of insects was begun in 1948 by the Insect Division of the Agricultural Experiment Station and it is still in progress at the present time. At the beginning, there were only a few people engaged in the research, but then the number of cases coming into the station was also small. Gradually the number of cases has increased, and the rate of reply has also been improved. In 1961, the number of cases received was 2,502; the number of replies made was 2,475, and the number of the pending cases was 27.

2) Classification

In the field of taxonomy, which is related to applied entomology, a mixing of similar main species of harmful insects is often discovered upon reexamination. The mixing, at times, of several similar species is evident in the case of cicadella ferruginea Fabricus and Nilaparivata lugens Stal. The effect of this cross breeding seems to be only a matter of changing scientific names but its impact on control and detection in applied entomology is indeed great.

The Agricultural Technology Research Center has published taxonomical studies centered on harmful and beneficial insects such as the studies of hamoguri bae and hanabae by Kato, the studies of cicadula sexnotata and yokobai, soldier bugs, ground beetles, ashibuto kobachi by Hasegawa, the studies of the larvae of lipidopteras by Hattori, the studies of hirata aba by Fukuhara. It has also published bulletins on insect identification, occurrence as connected with detection, and how to differentiate between similar species.

In recent years there has been almost a complete lack of researchers in other regions or prefectural agricultural experiment stations on taxonomy, yet the taxonomical study by Kobayashi, of the Tokushima Prefectural Agricultural Experiment Station, on the eggs and larvae of soldier bugs is noteworthy.

(3) The Physiology of Insects and the Work and Function of Insecticides

1) The Physiology of Growth

During the past twenty years the physiological study [illegible] growth of insects has made remarkable progress. This [illegible] mainly due to rapid progress in knowledge about the internal secretion of insects.

In Japan, entomologists started early on the study of insects harmful to rice crops, such as two brooded rice borers, [illegible], and yokobai. A general survey in this field was completed by about 1940. A study of the physiology of two brooded rice borer during dormancy formed a focal point which enabled the entomologists to detect the time of the first brood occurrence. The study of the growth physiology of the Nilaparvata lugens Stal and the Sogata furcifera horvath formed the basis for clarification of the condition of their wintering.

In the following an outline of problematic points in the growth physiology of two or three important harmful insects applied will be described.

The relationship between the growth of two brooded rice borer and its environment was studied in detail in the [illegible]. In the latter part of the 1940's the Ohara Agricultural Research Center established that at least three ecological types of Japanese two brooded rice borers existed.

The metamorphosis of two brooded rice borers is controlled solely by the prothorax gland as is the case with other insects. That is, when its larva reaches its last instar, the function of the corpus allatum falls, and the prothoracic gland is rapidly activated by stimulation from the brain, and thus metamorphosis takes place. In this case, if the impact of the hormone of the corpus allatum remains, an intermediate type between larva and pupa results. In this way various degrees of intermediate types are produced depending on the quantitative balance between the hormone of the corpus and the hormone of the prothorax gland, and thus the insect dies before it completes its metamorphosis. This will probably open the way for creating a new type of insecticide which will bring about death by destroying the hormone balance.

Dormancy refers to the phenomena of an insect suspending its growth in a certain stage due to a certain physiological impetus. As far as the dormancy of the larvae of the two brooded rice borer is concerned, it has been clarified that dormancy in this case, viewed from the standpoint of internal secretion, can be maintained by the inactivation of the cells of nervous secretion in the brain and the activation of secretion in the corpus allatum. (The Agricultural Technology Research Center). This study found theoretical support for the "heat adding method" which attempts to measure the depth of the dormancy of insects and to forecast the time of occurrence.

In order to clarify the wintering conditions of the Sogata furcifera Horvath and Nilaparvata lugens Stal, the Ministry of Agriculture and Forestry started special investigations in 1954 with good results. Through these investigations much basic research on the physiology of growth was conducted. It was clarified that Sogata Farcifer Horvath winters as an egg in Northern Japan and that it winters as an egg or as larva in Western Japan; tobiiro cicadula bemnotata also winters as an egg in many areas. (Agricultural Experiment Stations at Yamahata, Kanagawa, Horoshima, Miyazaki, the Agricultural Technology Research Center, and Kyushu Agricultural Experiment Station)

2) The Physiology of Nutrition

Researchers in biology and chemistry are gradually clarifying the nutritional needs of the insect and its metabolism processes.

Study on the nutrition physiology of the two brooded rice was taken up and developed by the Agricultural Tech. Research Center. In this study a non-bacterial synthetic diet was used successfully. As a synthetic diet for the two brooded rice borer, casei, dextrose, inorganic salt, cholesterol, dried yeast, rice water extract, and fiber were added to water and agar-agar. This mixture was then heated and sterilized for use. When the sterilized egg is inoculated with this sterilized mixture, the larva can be grown without bacteria.

Artificial food was made from aminic acid compounds which form protein as nitrogen sources. The result of breeding with one kind of amino acid after another was that ten kinds of animic acids such as arginine, histidine,

... isoleucine, tryptophan, methionine, lysine, threon- ... valine, and phenylalanine are not compounded within the ... and they must be taken from food. In contrast to this, other kinds of amino acids are compounded within the body.

A similar method was used to investigate the vitamin ... of the insects. It was found that fat-soluble vitamins were not needed, while the vitamin B group was strongly needed. Even a slight amount of B_1, B_2, B_6, pantotheic acid, yosan, nicotinic acid, biotine has marked impact on the growth of the two brooded rice borers, and when any of them are ... lacking, it hinders the growth of the larva. The growth elements in small amounts including vitamins have important significance in connection with enzymes, and it offers suggestions for the study of anti-metabolism agents.

Dextrose, fructose, and cane sugar have been found, from the breeding test and the study of the digestive enzyme, to be nutritive carbohydrates. Fat is needed for materials which are compounded within the body, but it was found that certain kinds of fatty acids hinder growth. Cholesterol is an indispensable nutritive element and large amounts in the diet are necessary. The fact that cholesterol cannot be compounded within the body is one of the greatest differences between insect and higher animal metabolism.

This investigation of the basic nutritive elements did not explain the nutritional necessity of rice plant parasitism for the two brooded rice borer. This seemed to indicate that rice plants had certain other matters that attracted the rice borer; extraction and separation of rice plant elements was carried out. An ingredient was separated from the neutral division of the rice plant and this was named oryzanon. When chemically studied, this was found to be P-methulacetophenone.

With this basic nutritional research as a foothold, the growth of the two brooded rice borer, the phases of rice change during its growth period, and the relationship between rice growth and its damage by the two brooded rice borer became clear. In the post-war period the cultivation pattern of the rice crop was changed due to progress with insecticides. The cultivation methods used to gain an increased yield, early planting and much fertilization, became possible; naturally the phases of the insect's occurrence also changed. Depending on the growth of the rice, there is a period suitable for

the parasitism of the two brooded rice borer, and a period that is not too c ceive to it. The on for this is that when an ade quantity of nit n fertilizer is applied, the rice c becomes suitable r the two brooded rice borer, for it creases the prot content in the rice and decreases conv ly the hydrocar ate contents. High protein food is the most suitable for two brooded rice borer, and a cultivation method that i eases the protein of rice also invites the increase of the rice borer during the growth period.

The quantity of silicic acid is related to the occurrence of insects harmful to rice. It has been pointed out that in the region in which the two brooded rice borer constantly occurs, the quantity of silicic acid in the soil and irrigation water is small. The relationship between silicic acid and the two brooded rice borer will be treated in the section dealing with resistence.

Various improvements have been made in the manufacturing of artificial food for the two brooded rice borer for the purpose of continued breeding. Thus it was possible to produce eight generations. It is extremely difficult to breed outdoor insects that are being fed on an artificial diet. Thus problems remain and concentrated efforts are being made to solve them.

The study of a synthetic diet for the two brooded rice borer naturally stimulated similar research with other insects. Thus the study of a synthetic diet for Yotomushi, Hasumon yoto, Kohamon hamaki, and Nashi shinkuimushi was made (at the Agricultural Technology Research Center, Nagoya University, Tea Experiment Station, and Okayama University), and artificial diets for them were manufactured.

3) The Action of Insecticides

a) Skin penetration (skin resistence)

Among the studies of this aspect, the one by Suwanai (Agricultural Technology Research Center) merits attention. He examined the physical-chemical method, the phenomenon that when parathion, and γ BHC are contacted by insects in an aqueous solution they are rapidly absorbed by the insects.

Next, he collected the fatty matter from the epidermis of callosobruchus chinensis Linne, and found that it had

hydrocarbonate as the main ingredient. Then he proved that the absorption and penetration of this epidermis and the distributive nature of these chemicals on this fatty matter and water were related to the effectiveness of various chemicals. He expanded this idea, and measured the distributive nature of the chemicals on the entire fatty component of the insect tissues. Then he put water through the combinations of various insects and chemicals. He proved, as the results of the comparison between this and the effectiveness of chemicals reveal, that the affinity of chemicals to the fatty matter of insects and the speed of penetration are closely related to effectiveness.

b) Activation, counteraction, excretion, and accumulation of chemicals (resistence of the body)

The research on this resistence of the body has attracted the most attention in respect to selective insecticide action and to the solution of the problem of insecticide resistence.

Recently, the problem of the two brooded rice borer's resistence to parathion was investigated, and it was proved to be the extreme speediness of the enzyme hydrosis of parathion which brought about the resistance, in other words a powerful counteraction (Kojima). The cause of the resistence of cicadella ferruginea Fabricus to malathon was attributed to the differences in counteraction.

On the other hand, contrary to commonly accepted knowledge that in the case of insects that resist DDT, DDT is turned to DDE by dehydrochloric acidization, Tsukamoto (Osaka) announced for the first time that in the case of drosphila which resists DDT, it is counteracted by keltene which is the ethanol type derivative of DDT. It was found that this counteraction also takes place in other insects.

Fukami (Agricultural Technology Research Center) has conducted research on the activation and counteraction of organic phosphoric chemicals in rats and two brooded rice borers, as the cause of selective insecticide action of organic sulphuric chemicals in higher animals and insects.

c) The sensitivity of the Points of Application

It is said that almost all insecticides cause nerve poisoning, and the point of application of chemicals is at the central nerve cord of insects. In discussing the chemical structure and action of insecticides in general, chemicals and the death of insects were considered to have a direct relationship in the past, and the many factors related to this often resulted in confusion. Therefore, in order to reduce the related factors, research on the primary action of chemicals was conducted; it developed into the large field, impact of chemicals on the central nerve cord. Next, because the nerves of insects were obviously related to the selectiveness of insecticide action, the nature of insect nerves was investigated. Electro-physiological research in this field has been conducted by Yamazaki, and Taruhashi (Tokyo University). It was known that DDT, unlike other insecticides, is effective in low temperatures. They proved this is because the sensitivity of DDT to the nerves of insects is strong at low temperature. They estimated also that the primary action of DDT was either the excitation of metabolism or changing of the permeation of ions by the physical-chemical action to the nerve membrane.

Kanehisa (Nagoya University) conducted research on the action structure of organic phosphoric insecticide, and has examined the nature of estorase, its point of application. Kanehisa, in examining thearomatic, aliphatic esterase of various insects, used enzyme activation hitoloically and chemically, and used cell partitions for comparison. He separated various kinds of esterase by using zymonograph as the base for the selective insecticide action of organic phosphoric insecticides, and sought the difference between higher animals and various insects. Similarly, Saito (Nagoya University) has pursued research on the selective insecticide action of shradan which is a permeating insecticide. He did not recognize a difference in the epidermis permeation and in external discharge action of shradan in sensitive and non-sensitive insects, but found out that there was a difference in the distribution phase of chemicals in the bodies of insects, and that larger amounts of chemicals were accumulated in the central nerves of the sensitive group than in those of the non-sensitive group. He reports that the corselet nerves of the insects of the non-sensitive group show a thin and strong structure, and those of the sensitive group are made of a thin double structure. The cause of the selectivity is reported to be related to permeation.

d) On the Inquiry into the Metabolism Among Various Living Organisms by the use of Insecticides Marked with Isotopes

Due to the development in radiological chemistry during the post-war period, the analysis of extremely small quantities of analytical products, impossible to measure in the pre-war period, became possible, and this technique was widely used in the research on the action structure of insecticides. Only a limited number of people are engaged in this, because there are only a few technicians, but many people ought to have an interest in this field in the future. Among the studies in this field, the research by Tomizawa (Agricultural Technical Research Center) is noteworthy. He has synthetized a tick-killing chemical by compounding S^{35} mark, P^{32} mark methyl parathion, malathon, and S^{35} mark, and has done research on the permeation and transition of these mark insecticides in insects, ticks, and host plants for these parasites, and on the identification of metabolism products. He has pointed out considerable differences in metabolism compounds among these plants.

It was known that the application of γ-BHC is effective against the first generation two brooded rice borer, and in order to have direct proof of this function, Ishi (Agricultural Technology Center) used C^{14}-mark γ-BHC. As a result, it was found that γ-BHC was absorbed from the root, too, and it also rose in capillaries on the leaf sheath, the surface of the stem, and gaps.

4) The Resistence of Crops to Insects

There is an extremely small number of instances that have clarified the essential character of resistence to insects even in other countries. In Japan research on the resistence to ine karabae (Tohoku and Chugoku Agricultural Experiment Station and Agricultural Technology Center), and the resistence to kuritama bachi (Horticultural Experiment Station) has been carried out. The results of the research have not shown the spawning selectivity of adult insects among crops but have shown that there is a difference in resistence depending on the growth and survival rate of larvae that were hatched in host plants.

(3) Ecology

1) Group Ecology

Kobayashi (1954-1960), Yoshimegi (1954-1958), Niho (1956-1957) studied the impact of chemical spraying on the insects groups in wet paddies. Yoshimegi discussed the disturbance of insects groups due to the spraying of a chemical (BHC) and the dynamics of the re-construction, while Kobayashi and Niho discussed the decrease of such natural enemies as spiders, koshikatabiro amenbo and the abnormal occurrence of cicadula sexnotata and yokobai due to the simplification of the group structure. Furthermore, in the field of research on the changes in rice plant cultivation methods and on the impact of the group control through chemicals on harmful insect groups, Chiba Agricultural Experiment Station (1956-1958), Hiroshima Agricultural Experiment Station (1954-1956), Itoga-Horikiri (1955-1956), Iwate Agricultural Experiment Station (1956-1959), Kagawa Agricultural Experiment Station (1954-1957), Kumamoto Agricultural Experiment Station (1956), Saga Agricultural Experiment Station (1957), Toyama Agricultural Experiment Station (1956-1958), and Suenaga (1955, 1959) investigated the econology of the main harmful insects, insects having a similar ecological position and of insects that are their natural enemies after artificial action is added.

2) The Ecology of the Population

The ecological study of insect population has been developed with the various ecological phenomena with its center on the population of the same species inhabiting the same place and the populations of different species that are closely related to these. Especially in the course of study on the experimental populations of insects harmful to stored grains, many new fields centering on the density of population have opened up. That is, the birth rate which determines the progress and decline of population of insects, the relationship between the birth rate and the death rate which determines the progress and decline of individual insect groups has been clarified, and the ecological phenomena of the density of experimental populations, including parasitic bees, have been theoretically clarified.

Following the study of these experimental populations, the mathematical research on the distribution structure of population was promoted in order to estimate the distribution and density of natural outdoor populations. That is, the

... distribution structure of two brooded rice borers, daikon ... and monshiro butterflies in the experimental fields was studied, and the experimental method for the estimation of density was clarified. Especially in the case of two brooded rice borers, the Shizuoka Agricultural Experiment Station, and Wakayama Agricultural Experiment Station examined, from the standpoint of the victim, the distribution structure over large areas and the method of sampling based on this.

The study on the composition of population and its change were examined with the main emphasis on the life table. Ito (1959) showed the survival curve of two brooded rice borers, and Kiriya examined the same thing on minami ao kamemushi. What is important, out of the results gained in this study on the life table, is the coming of the various crisis in the growth stages throughout the lives of the population. Through this the changes of population and the clues to their control can be gained.

3) Life History

Recently, at various institutions, active research has been continuously carried out on the re-examination of the life history of major harmful insects of major agricultural crops.

a) Diptera

Research on the insects harmful to rice crops was concerned with inehime hamoguribae, conducted at the Tohoku and Hokkaido Agricultural Experiment Stations (Kuwayama et al, 1955), Inekuro karabae at the Chugoku Agricultural Experiment Station (Okamoto et al, 1954), Research on some of the insects harmful to barley was on mugiha moguribae at several stations (Yabe, 1954; Mori et al 1957), on mugiki moguribae at Hokkaido University and Akita Agricultural Experiment Station (Nishijima, 1954; Hirao et al, 1958). The comprehensive research by Kuwayama et al made a great contribution to the field of detection and control. Among those discovered in the process of investigating insects harmful to soy beans at several places were daizune moguribae (Shimatsuji, 1956), daizusaya tamabae (Suenaga et al, 1955), daizukuki tamabae at Tohoku Agricultural Experiment Station (Yoshida, 1950), daizuki moguribae at Hokuriku Agricultural Experiment Station (Sugiyama, et al, 1955), daizu knoryubae at Okayama University, and daizu kiro kongryu bae (Koizumi, 1957). As to tamanegi bae which expanded its distribution

In the post-war period, Akita Agricultural Experiment Station (Koizumi, 1957) conducted research, and Hokkaido University (Hotta et al, 1958) did research on akaza moguri hanabae.

The research on kiuri kaganbo by Masaki (Agricultural Experiment Station, 1959) was detailed and it was one of the great achievements of recent years.

b) Lepidoptera

On moths, Fukuoka Agricultural Experiment Station carried out research on tamanagaya (Takiguchi, 1955), the Agricultural College conducted research on Kinuwaba (Ichinose, 1956, 1957), and Hokkaido Agricultural Experiment Station and Osaka Municipal College conducted research on various species of meiga and hamakiga. Among these, the research on awano meiga by Hokkaido Agricultural Experiment Station was developed into the ecological and taxonomical study of the males of the two species of ashiboso and ashibuto. (Takeuchi, 1959, Matsumoto, 1960) An epoch-making study was conducted on several important species of fruit-sucking moths at several places (Nomura et al, 1961). Among the insects harmful to the tea plant, Minamigawa (1950) clarified the life history of several important species including chaedashaku and unmonedashaku.

c) Hemiptera

Miyazaki and Wakayama Agricultural Experiment Stations conducted research on minami aokamemushi which suddenly appeared in rice fields following the introduction of early cultivation (Niho, Kiriya, Samejima, 1960). The life history of various species of cicadula sexnotata was investigated in connection with the investigation of wintering. Kyushu Agricultural Experiment Station conducted detailed investigation on Taiwan tsumaguro yokobai (Nasu, 1958). Also the research on various species of plant lice and kaigara mushi was carried out mainly by the researchers at various universities (Takahashi, Moritsu, and Tanaka, 1950).

(4) Damage Structure and Damage Assessment

Research on damage structure and damage assessment forms the groundwork for the economic assessment of damage caused by harmful insects, and it is an important point in control technique.

Earlier, Kawata (Agricultural Experiment Station) had done research on the damage structure of two brooded rice borers. Since then varied research was carried out on the insects harmful to rice and dry field crops. An outline is introduced in the insect experiment method by Tamura (1959), but most of the previous study deals with the ecological analysis of damage. Thus the physiological and chemical elucidation of damage structure is a field of research left for future exploration.

The mode of damage caused by harmful insects varies greatly with the change in the cultivation pattern of crops. Some results were obtained recently through the damage analysis from new viewpoints.

There are detailed data on the damage assessment of two brooded rice borers, three brooded rice borers, cicadula sexnotata, karabae, kiriuji, tobimushimodoki, and plant lice. For instance, in the case of rice borers, the correlation between the damage rate or the volume of occurrence and the rate of decreased yield was investigated, and this presented the formula for calculating the rate of decreased yield in other areas.

But as Takagi (1959) pointed out, the research on two brooded rice borers required detailed investigation of each stalk of rice, entailing a large amount of labor. Thus as a practice, rice plants in a single experimental patch were investigated. This might be good for the observing the results of chemical tests only, but for the assessment of damage in a certain entire area another investigative method must be considered. Therefore, Shizuoka and Wakayama Agricultural Experiment Stations began a solution to this problem in the form of a special investigation sponsored by the Ministry of Agriculture and Forestry, with satisfactory results. The findings will be published shortly.

(5) Live Examination

Due to the rapid progress in organic synthetic insecticides since the end of the war, it has been possible to control a large number of harmful insects by the use of proper insecticides. Behind this progress in insecticides, the live examination method, which determines the insecticide suitability, has played a large role. Live examination is herewith described by dividing it into two types, indoor test and field test.

The goals of the indoor test are, the screening of new compounds and agents, the quality control of chemicals, the biological estimation of residue, and the test of resistonce. These are checked in the laboratory before judging actual effectiveness at the test field. Accordingly, sample insects are not necessarily those insects that are the direct objects of tests. Thus house flies, mosquitoes, and rice weevils that can be easily raised indoors are offered for testing. The species of sample insects, conditions for their raising, and medication methods are closely related to the results of indoor tests. Tokyo University, Kyoto University, Chemical Research Institute, Nagoya University, Agricultural Technology Research Center, Farm Chemical Testing Center, and Kyushu Agricultural Experiment Station have all made efforts to establish the indoor testing method. As a recent remarkable trend, Japanese farm chemical companies and pharmaceutical companies are regarding the live testing aspect as important to their own needs, expanding facilities, and are carrving out research by assembling qualified personnel. Although they would have different purposes, the national research agencies should rapidly expand their facilities and personnel for further study.

The indoor live testing method is more sensitive than the chemical estimation method in some cases. Since it is repeatable when conditions are strictly enforced, it should be developed further, in conjunction with the chemical estimation method.

Field tests are carried out in the test field on the harmful insects that are the direct objects of manufactured insecticides. The size of an area, repetition, and the analysis of results vary with the species of object insects, but they have become more accurate with the introduction of modern statistics. The frequency, timing, and density of chemical spraying have been investigated through a national organization centered around the agricultural experiment station in each area. We must not overlook the fact that the rapid progress and dissemination of insecticides have kept all regional agricultural experiment stations and prefectural agricultural experiment stations busy with the field tests of these insecticides.

In live tests, the standardization of sample insects, methods, and chemicals is the most important problem. Although independent live tests carried out at each research center are of significance, their comparison is impossible unless they are standardized. In view of the fact that resistant insects are appearing due to the heavy use of insecticides

in recent times, it will be necessary to rapidly establish the standardization of the live test method.

C. Main Tests and Research Projects Presently Under Way

The following are the main research projects under way.

1. Occurrence and Detection of Harmful Insects

(1) The experimental detection method of rice borers -- Hokuriku Agricultural Experiment Station, and Kyushu Agricultural Experiment Station

(2) The experimental detection method of cicadula sexnotata and yokobai -- Kyushu Agricultural Experiment Station

(3) The detection method of occurrence of fruit trees codling insects -- The Main Horticultural Experiment Station, and Morioka Sub-station

(4) The detection method of occurrence of yanone scale insect -- Horticultural Experiment Station (Okitsu)

(5) The detection method of occurrence of leaf ticks -- Kurume Sub-station of the Horticultural Experiment Station

(6) Analysis of the fluctuations in the occurrence of rice karabae -- Hokuriku Agricultural Experiment Station

(7) Occurrence of insects harmful to tea plants by the use of a detection lamp -- Tea Experiment Station

(8) Investigation of fluctuations of occurrence of rice yoto -- Kagoshima Agricultural Experiment Station (designated test)

(9) Growth of harmful insect populations while rice plants are young -- Hokuriku Agricultural Experiment Station

2. The Planting System and the Occurrence of Harmful Insects

(1) The aspects of occurrence of harmful insects in the direct planting cultivation of wet rice -- Tohoku, Chugoku, and Kyushu Agricultural Experiment Stations

(2) The ecology and damage of two brooded rice borer in the direct planting cultivation of wet rice -- Tokai and Kinki Agricultural Experiment Stations

(3) The occurrence of the first and second broods of two brooded rice borers in the Tohoku region -- Tohoku Agricultural Experiment Station

(4) The environment of occurrence of rice himcha moguribae -- Tohoku Agricultural Experiment Station

(5) Phase of occurrence and ecology of occurrence of cicadula sexnotata and yokobai -- Hokuriku and Kyushu Agricultural Experiment Stations

(6) The analysis of the factors for the fluctuation in the density of population of minami aokamemushi -- Wakayama (designated experiment)

3. The Ecology of Virus-carrying Insects

(1) The wintering of himetobi unka and its occurrence in spring -- Agricultural Experiment Station and Shikoku Agricultural Experiment Station

(2) Study on the relationship between himetobi unka and rice varieties -- Chuoku Agricultural Experiment Station

(3) The assessment of natural enemies as the biological environment resistence of himetobi unka -- Agricultural Experiment Station

(4) The analysis of increase and decrease of population of poisonous cicadula sexnotata and yokobai -- Kyushu Agricultural Experiment Station

4. Insects Harmful to Pastures and Fodder Crops

(1) The investigation of occurrence of harmful insects -- Agricultural Technology Research Center, Agricultural Experiment Station, Hokkaido, Chugoku, Shikoku, Kyushu Agricultural Experiment Stations

(2) The ecology and control of kisuji i hamushi of fodder -- Hokuriku Agricultural Experiment St on

5. The Utilization of natural enemies

(1) Study of the species, distribution, ecology, and mass raising of kona scale insects as natural enemies -- Horticultural Experiment Station

(2) Study on the breeding of Aschersonia sp, a natural enemy of mikan konajirami -- Horticultural Experiment Station

(3) Study of pathogenic micro organisms of fruit-sucking moths -- Horticultural Experiment Station

(4) Study on the multiplication of scale insects and their natural enemies -- Kurume Sub-station of Horticultural Experiment Station

(5) The elimination of the adverse impact of chemical spraying on the activity of natural enemy insects -- Kurume Sub-station of Horticultural Experiment Station

(6) Study on the natural enemies of the kuwashiro scale insect -- Tea Experiment Station

(7) Study on the natural enemies of kokakumonhama -- Tea Experiment Station

(8) Study on the natural enemies of Kanzawa hadani -- Tea Experiment Station

(9) Investigation of parasitic bees and adult parasitic flies on the egges of minami aokamemushi -- Wakayama (designated experiment)

6. Effective Application of Insecticides

(1) Examination of the adhesion of liquid chemicals to various crops -- Kyushu Agricultural Experiment Station

(2) Study on the soil application of NAC -- Kyushu Agricultural Experiment Station

(3) Study on the effectiveness of soil and underwater application of BHC -- Tohoku, Tokai, Kinki, and Chugoku Agricultural Experiment Stations

(4) The control of inekarabae by the soil application of insecticides -- Tohoku Agricultural Experiment Station

(5) Improvement of the application of insecticides against insects harmful to soil -- Agricultural Experiment Station

(6) The effectiveness of water-surface application of low-poison organic sulphuric chemicals -- Hokuriku Agricultural Experiment Station

7. Studies on the Chemical Control of Major Harmful Insects

(1) Tsumaguro yokobai , himetobi unka -- Chugoku and Kyushu Agricultural Experiment Station

(2) Tamanegibae -- Hokkaido Agricultural Experiment Station

(3) Daizusaya tamabae -- Agricultural Experiment Station

(4) Hasumon yoto, and Awa yoto -- Chugoku Agricultural Experiment Station

8. Resistence of Harmful Insects to Insecticides

(1) The testing method of effectiveness of insecticides against harmful insects -- Agricultural Technology Research Center

(2) Study on the structure of resistence appearance -- Agricultural Technology Research Center

(3) The effectiveness of chlorine insecticides against tamanegi bae, and tanebae -- Hokkaido Agricultural Experiment Station

(4) The effectiveness of organic phosphuric chemicals against the apple-leaf tick -- Hokkaido Agricultural Experiment Station

(5) Study on the sensitivity of tsumaguro yokobai and himetobi cicadula sexnotata to various insecticides -- Hokkaido Agricultural Experiment Station

9. Damage of Crops by Harmful Insects

(1) Analysis of the factors for fluctuation in the damage of wet rice by two brooded rice borers -- Hokuriku Agricultural Experiment Station

(2) Analysis of the factors for fluctuation in the damage by cicadula sexnotata and yokobai -- Hokuriku Agricultural Experiment Station

10. Insects Harmful to Stored Food

(1) The multiplication rate of rice weevils -- Food Research Center

(2) The lifetable of moths -- Food Research Center

(3) The detection of harmful insects prior to their activities -- Food Research Center

(4) Study on the use of fumigating chemicals -- Food Research Center

(5) Study on the prevention of damage of rats by antibiotics -- Food Research Center

11. Study on Insects Harmful to Fibers and Mulberries

(1) Study on the chemical control of insects harmful to the mulberry -- Sericultural Experiment Station

(2) Study on the control of mulberry nomatodes -- Sericultural Experiment Station

(3) Study on the ecology and control method of katsuobushi mushi and iga's -- Sericultural Experiment Station

(4) Study on the selective poison of farm chemicals with emphasis on silk-worms -- Sericultural Experiment Station

(5) Study on the detection method of occurrence of insects harmful to mulberry farms -- Sericultural Experiment Station

(6) Study on the ecology and control of mulberry-leaf insects -- Sericultural Experiment Station

12. Study on Insects Harmful to Forests

(1) Basic research on the detection of occurrence of dead pine needles -- Forestry Experiment Station

(2) Classification and distribution of pine boring insects -- Forestry Experiment Station

(3) Study on the occurrence structure, multiplication, and density of boring insects -- Forestry Experiment Station

(4) Spread of damage of boring insects in areas damaged by wind -- Forestry Experiment Station

(5) Ecology and control of meiga and hamagaki that are harmful to needle-leaf trees -- Forestry Experiment Station

(6) Control of plant lice that are harmful to needle-leaf trees -- Forestry Experiment Station

(7) Study on the control of insects harmful to tree nurseries -- Forestry Experiment Station

(8) Control of tamabae which damages needle-leaf trees -- Forestry Experiment Station

(9) Study on the control of the cedar leaf tick -- Forestry Experiment Station

(10) Classification and distribution of natural enemy micro-organisms -- Forestry Experiment Station

(11) Biological control by virus diseases and parasitic bees -- Forestry Experiment Station

(12) Study on smoke-generating chemicals -- Forestry Experiment Station

13. Harmful Birds and Animals

(1) Detection of occurrence of wild mice -- Forestry Experiment Station

(2) Study on the control of wild mice -- Forestry Experiment Station

(3) Study on the control of the wood-mouse -- Forestry Experiment Station

(4) The breeding of wild rabbits -- Forestry Experiment Station

(5) The control method of wild rabbits -- Forestry Experiment Station

14. Harmful Nematodes

(1) The classification and identification of parasitic nematodes -- Agricultural Technology Research Center

(2) The physiology and ecology of nematodes -- Agricultural Experiment Station

(3) An analysis of the parasitic nature and damage of nematodes -- Agricultural Technology Research Center, Agricultural Experiment Station, and Hokkaido Agricultural Experiment Station

(4) The resistence of soy-bean varieties to soy-bean heterodea -- Hokkaido Agricultural Experiment Station

(5) The resistence of potato varieties to soy-bean pratylenchus spp. -- Nagasaki (designated experiment)

(6) The control method of heterodera -- Hokkaido Agricultural Experiment Station

(7) The control method of beet meloidognyne -- Hokkaido Agricultural Experiment Station

(8) Study on the control of nematodes in the rotation crop system -- Hokkaido Agricultural Experiment Station

(9) The control method of pratylenchus spp. -- Agricultural Experiment Station, Tea Experiment Station, Nagasaki (designated test)

(10) Investigation of nematodes parasitic to pasture grass -- Agricultural Technology Research Center, Agricultural Experiment Station, Hokkaido, Chugoku, and Shikoku Agricultural Experiment Stations

15. Basic Problems

(1) Study on the identification and classification of insects -- Entomology Division of Agricultural Technology Research Center

(2) Study on the nutrition and metabolism of insects -- Entomology Division of Agricultural Technology Research Center

(3) Study on the investigation methods and causes for change in the number of insect entities -- Entomology Division of Agricultural Technology Research Center

(4) The occurrence structure of harmful insects -- Entomology Division of Agricultural Technology Research Center

(5) Study on the action structure of insecticides -- Entomology Division of Agricultural Technology Research Center

(6) The dispersion of nematode-killing chemicals applied to soil -- Farm Chemical Division of Agricultural Technology Research Center.

(7) The metabolism of 1-naphythyl-N-methyl carbamate in plants and insects -- Environmental Division 1, Kyushu Agricultural Experiment Station

(8) The absorption and Transition of r-BHC in wet rice -- Farm Chemical Division of Agricultural Technology Research Center

(9) The separation and estimation method of insecticides -- Farm Chemical Division of Agricultural Technology Research Center

(10) Ecological Studies

1) Fuki meiga -- Hokkaido Agricultural Experiment Station; 2) midorihime yokobai -- Tea Experiment Station and Kyushu Agricultural Experiment Station; 3) Sejiro unka modoki -- Kyushu Agricultural Experiment Station; 4) soybean stalk tamabae -- Agricultural Experiment Station; 5) Inayoto -- Kagoshima (designated experiment); 6) Minami ao soldier bug -- Wakayama (designated experiment); 7) Tea Hosoga -- Tea Experiment Station; 8) Kanzawahada tick -- Tea Experiment Station; 9) Awa yoto, Hasumon yoto -- Chugoku Agricultural Experiment Station

B. Priority Test and Research Topics in the Future

1. Study on the nutrition, metabolism, and artificial breeding of insects

Knowing the occurrence of insects is important in the development of techniques on detection. It is necessary, especially for the quantitative detection of insects. It is normal from the physiological standpoint to pursue the occurrence structure from the aspects of nutrition and metabolism. And in order to facilitate such research, it is imperative to establish artificial breeding method of insects.

2. Study on the action of insecticides and insects with resistence to chemical

It is obvious that the phenomenon of ineffectiveness of insecticides, that is, the problem of resistance, will assume more and more importance in the future. In the future the need for the development of low-poison farm chemicals will be called for more than at present. Therefore, in our countermeasures, the clarification of selective insect-killing action, which forms the basis for the afore-mentioned problem, becomes absolutely necessary. For this need, study along the following lines will become necessary.

(1) We are to promote the physical and chemical study on the permeation of insect skin and the protection sheath of the nervous system, and search for the cause of the selectivity in the permeation of chemicals.

(2) We are to improve the technique of measuring radioactivity in the permeation of isotope -- mark insecticides and histological distribution study, to identify metabolism products, and search for the cause of selectivity from the difference in products in such cases.

(3) We are to conduct research on enzyme counteraction, which is the largest cause of selectivity. Through this study we are to discover chemicals (for instance, the use of TOCP in malathon resistence, and the use of orthochlor DDT in DDT resistence) that obstruct counteraction, and use them as co-power agents against resistant insects. That is, we are to promote research on the action of co-power agents.

(4) In compounding drugs we are to clarify the selectivity of drugs that have known selectivity, and we are to use

than selectivity radical as a base. For instance, with pyrethrine, nicotine, and rotenon and such natural source insecticides with low-poison, only a comparatively low level of resistance to these insecticides has been found. Therefore, we are to study the chemistry and action structure of natural source insecticides in order to develop more effective analogous compounds.

(5) We are to formulate new techniques capable of clarifying the physiological and chemical nature of micro viscera, such as insect nerves (for instance, the metabolism of nerves and the study of counteraction enzymes), and thus search for the cause o' selectivity.

(6) We are to use hormones in the control of harmful insects.

(7) We are to discover natural or synthetic inducement agents or avoidance matters in carrier insects.

(8) We are to develop steroids that have an irreversible action as the particular growth and multiplication adjustment agent and of the antagonistic agent of vitamins, and the study of antibiotic matters for the control of symbionts of insects

3. Study on insects carrying plant virus disease

The future research projects on plant lice, cicadula sexnotata and yokabai that carry plant viruses touches upon the two aspects of physiological ecological study of the migration and carrying of adult insects, and the physiology of insects containing viruses.

(1) Study on the migration and carrying of adult insects

The study on the migration of adult insects which become the source of the main carrying (or the primary carrying source) outdoors has been, so far, limited to the understanding and analysis of the phenomena. In the future, the physiological and ecological inquiry into the movement and carrying of adult insects will become a more important research topic in connection with the diffusion of virus diseases.

(2) Study on the insects containing virus

Some virus carrying insects have an affinity for (or infectious nature of) viruses , others have none. They have

different characteristics depending on the kinds of virus and the kinds of virus-carrying insects.

In the future the hereditary study of these physical characteristics is necessary in order to clarify various natures of the poison-containing physical characteristics. Then, for the clarification of the multiplication and egg infection structure of viruses in the body of insects containing poison, an inquiry must be made into problems in multiplication of plant viruses in the bodies of insects by using morphological study by electron microscope and histological biophysic and serology techniques.

Thus when study on the insects containing virus and its movement and carriage progresses, it will be possible to directly examine insects containing virus by examining their bodies, and furthermore to establish the method to detect beforehand the occurrence and movement of these virus carrying insects.

4. Study on the detection of the occurrence of harmful insects

(1) The detection method of occurrence of insects carrying rice virus pathogen

At present the control of the insects that carry it is the only method of controling rice virus diseases, but the control in this case is markedly different from the general case of control of harmful insects. That is, it is necessary to completely eradicate insects carrying the pathogen in order to control the occurrence of the disease. This requires a great deal of money. If the detection of occurrence of insects with pathogen can be accurately established, this will immeasurably contribute to the reduction of the expense needed for control.

(2) The detection method of occurrence of insects harmful to fruit trees

Because the present control of insects harmful to fruit trees is carried out by spraying insecticides, without the accurate detection of their occurrence, control is very costly. At present, some observations are being made on the detection of occurrence of the tangerine-leaf tick. But only a little basic research has been done on the detection of occurrence of a few scale and codling insects,

and it will be necessary to strengthen this research.

(3) The detection method of insects harmful to dry field crops

When the ecology of occurrence of various insects harmful to dry field crops is clarified, it will be necessary to promptly undertake research.

5. Study on the ecology of occurrence of harmful insects under the new planting system.

It will be necessary to inquire into the ecology of occurrence of harmful insects under the forthcoming new planting system including the direct planting cultivation by using large machines, and to establish an economical control method by the effective application of insecticides.

6. Study on the ecology of occurrence of insects harmful to general dry field crops including pasture grass and on the establishment of effective control methods

Because there has been no organized basic research on insects harmful to pasture grass and general dry field crops, it will be necessary to make ecological and physiological inquiries into the environment of their occurrence, to consolidate the base for the detection of occurrence and to establish effective control methods.

7. Study on the utilization of natural enemies

Research has been undertaken on the insects harmful to perennial crops, in terms of the utilization of natural enemies. It will be necessary, in the utilization of natural enemies, to actively import these natural enemies from foreign countries and utilize them, in addition to already available ones, on the major insects harmful to farm crops in general. In the past, the utilization of insects as natural enemies tended to be predominant, but it will be necessary in the future to carry out research on the utilization of micro organisms and insect viruses. Especially in the case of insects harmful to forestry, which places various limits on the spraying of chemicals, it is necessary to actively carry out research on the utilization of pathogenic micro organisms, natural enemy insects, and beneficial birds.

8. Study on the effective application of insecticides

The success in the soil and underwater application of [illegible] seems to have opened up a new aspect in the application of insecticides. The examination of this kind of application method on various other farm chemicals is desirable and also its action should be studied.

9. Study on the damage assessment method and the investigation of actual conditions

Rapid progress has been made in the past several years in research in this field. But there are several fields of research on major harmful insects which still remain unexplored. Especially in the investigation of actual conditions, research in program formulation, in anticipation of using electronic computers for the detection of occurrence, must be given importance.

10. Development of new methods of control of harmful insects, including the utilization of atomic energy

In the United States a new method of control has been established by emasculating male insects of certain species by the application of the γ-ray and releasing them, causing the sterility of the female. We should make efforts in this field in Japan. Also the utilization of incentive matters and hormone should be taken into consideration.

11. Study on harmful nematodes

The species of nematodes, which are parasites on annual dry field crops, have been quite clearly understood, and consequently the ecology of certain nematodes and control methods by nematode-killing agents have been studied. On pasture grasses, tea plants, fruit trees, and timber, however, little research has been carried out. Therefore, it will be necessary to do research on the species of and damages caused by parasitic nematodes that have not been previously studied and on the ecology and control of major nematodes. It will be necessary to establish more economical methods of control of nematodes harmful to dry field crops whose control method was found by the use of nematode-killing agents. It is also considered important to establish the detection method of damage and occurrence of nematodes.

III. FARM CHEMICALS

A. A history of test and research

In the Taisho (1921-1926) period lighting oil (for cicadula sexnotata), bordeau liquid, lime sulphur, pyrethrum, and synthetic resins became available for practical use. Sulphuric acid nicotine, lead arcenate, and chloride picric acid were manufactured in Japan. Toward the last part of the Taisho period, chemists specializing in farm chemicals were assigned to the entomology divisions of agricultural experiment stations, and this marked the beginning of the study of farm chemicals. At that time, at the Physics and Chemistry Research Center, research on derris and pyrethrum was undertaken by organic chemists.

In the Showa period (1926-to the present), farm chemicals became important production materials for fruit trees and vegetables, and the volume of their use was increased. Moreover, the number of testing and research personnel specializing in farm chemicals was gradually increased. Thus research on the control of harmful insects and blights with farm chemicals has progressed.

After the outbreak of the China Incident (1937), however, raw materials for farm chemicals became scarce, and research on substitute chemicals was undertaken. Thus, in place of lead arcenate acid and resine synthetics, soda synthetic were studied.

During the Second World War, the study and utilization of organic synthetic farm chemicals became brisk in Europe and America. After the war, DDT, BHC, and other powerful chemicals were introduced in Japan.

In order to cope with this situation, the Division of Farm Chemicals was founded anew in the Agricultural Experiment

Section, and it began to undertake the improvement and utilization of insecticides and germicides. (In 1948 the Farm Chemicals Inspection Institute was created, charged with the inspection and control of farm chemicals, and at the same time with the improvement of analytic methods and inspection methods needed for this purpose.) The Division of Farm Chemicals was changed following the reorganization of the Agricultural Experiment Station in 1950 into the Department of Farm Chemicals of the Agricultural Technology Research Center. During this period, farm chemical researchers were assigned to the Kyushu Agricultural Experiment Station in 1953, and to the Tohoku Agricultural Experiment Station in 1955, in order to undertake regional research on farm chemicals and to provide guidance.

In the field of spraying farm chemicals, the spraying of rice was widely practiced and improvement, for effective spraying, was attempted. In the post-war period, powdered chemicals were added. Recently, granulated chemicals came into use. Thus with the progress made in the spraying devices and the expanded use of helicopters for farm chemical spraying, the technique has become very effective.

B. The results of testing and research

Because it requires the cooperation of diverse specialized fields for a material to become practical as a farm chemical, it requires a great deal of time and money. The researchers in the ecology and control of harmful insects, have, in particular, been mobilized to a large extent for the improvement of inspection and use of farm chemicals, with considerable results. It is obvious that the cooperation between chemists and biologists is imperative for pursuing test and research projects. Therefore, training of specialists in these fields is desired.

1. The synthesis of materials for farm chemical use

The synthesis of the derivatives of farm chemicals and new compounds has been quite widely and systematically carried out on organic phosphuric compounds, organic tin compounds, organic arsenic compounds, carbamate compounds, alkyl phenol compounds, and interfacial active compounds. Consequently, notably effective materials have been discovered. Also the synthesis of radioactive compounds has been carried out by using isotopes, and has been used for determining the effectiveness of these compounds, for research on the

relationship between chemical structure and physiological actions, and on the biochemical study of farm chemicals.

2. Antibiotics

In the field of the application of antibiotics in farm chemicals, the effectiveness of cycloheximide against tamaengi beto disease, glyseofulbine against apple moniriya disease, anti-mycine against peach anthracnose, and streptomycine against tobacco wild fire disease has been acknowledged. Blasteidin S, found by research aimed at discovery of a farm chemical, is noteworthy as a Japanese product for the control of rice blast disease and also in terms of future prospects in research on antibiotics for farm chemical use.

Blasteidin S is produced by actinini-form germs separated from Japanese soil. While its antibiosis was not strong against rice blast disease in the test tube, it showed an excellent remedial effectiveness in the experimental field.

Because blasteidin S checks the protein synthesis of rice blast disease bacteria, the bacteria growth is halted. Thus diseased spots do not develop, nor do they form spores. Serocidin has been discovered and is effective against white rice blight disease.

3. Farm chemical analytic methods

The analysis of farm chemicals is generally divided into chemical, physical, and biological analysis. In terms of the quantity of testing samples, it is divided into ordinary analysis and micro analysis, and in terms of operation it is divided into general analysis and rapid (or simplified) analysis. Ordinary analysis has contributed to the determination of grades of chemicals and to quality control of products, while micro analysis has contributed to the measurement of residue of farm chemicals, to their biochemical study and thus to such administrative aspects as guidance in the use of them, and inspection and control.

For instance, it clarified the chronological change of organic phosphuric, and powdered chemicals and contributed to the quality maintenance of chemicals through the search for decomposition prevention agents. Also the study of the surviving effectiveness of sprayed chemicals and of the mixing

[illegible] farm chemicals were developed by means of the analytical [illegible]. Furthermore, by combining chemical unit operation with biological analysis of the red pea weevil, micro farm chemicals in ground water, permeation and transition of farm chemicals, the relationship between fatal doseage and iatal speed were measured.

The object chemicals for micro analysis research were mainly parathion, malathon, EMC, and organic mercuric preparations. These are effective in micro volumes. Their use is widespread and they are important.

4. Manufacturing of farm chemicals

In the field of manufacturing farm chemicals, research has been carried out in order to improve powdered chemicals, whose use was rapidly increased with the appearance of new chemicals since the end of the war. Hydrated chemicals, emulsifiers and adhesive chemicals are also being studied so that they will suit actual insect control conditions in Japan. The quality of emulsifiers has been markedly improved due to the change of emulsion chemicals from soap and sulfonated oil to synthetic interfacial active agents.

The methods of measuring various physical characteristics of farm chemicals was proposed for physical and chemical study as a part of the basis for studying the manufacturing of farm chemicals. The study of physical characteristics, however, lags behind that of chemical ones. The impact of the effectiveness of adding emulsifier to farm chemicals and the relationship between grain size and effectiveness at the experimental field cannot lead to a simple conclusion, because it is related to farm chemical types and the spraying method.

5. The action of farm chemicals

While study is being made of the biochemical analysis of farm chemicals, their diffusion, and shift permeation in the tissues of living organisms, the majority of questions are unanswered in many cases and even the terminology still lacks uniformity. For this study of permeation, shift and analysis isotopes were used.

In terms of the environment of the experimental field, the adsorption, absorption, capillarity, resolution, and discharge of farm chemicals in ground water and in soil are

closely related to the manifestation of the effectiveness and harm of farm chemicals. Therefore study was made of organic sulphuric chemicals, organic mercuric chemicals, and BHC.

6. The improvement of farm chemicals directly connected with the spraying method

Since the end of the war much progress has been made in the improvement of vaporizing and in new spraying methods. This served as the forerunner to the use of large farm machines. The study on spraying methods has been important, together with the application to objects of spraying, harmful insects, and the examination of control effects. (See air spraying, p. 85) For instance, by mist machine and helicopter, 1/8 and 1/20-50 concentrated solution respectively, are sprayed. Therefore, improvement has been made in chemical types to meet this effectively, in terms of the harm of chemicals, machines and tools, applicability and other practical functions. In the case of powdered chemicals, their diffusion and adhesion have been studied to contribute to their practical use and study.

C. Main testing and research projects under study

(1) The application of organic metallic compounds to farm chemicals Agricultural Technology Research Center

(2) The application of carbamate compounds to farm chemicals -- Agricultural Technology Research Center

(3) The application of mold-resistence antibiotics to farm chemicals -- Agricultural Technology Research Center

(4) The galenical pharmaceutical study of blastcidin S -- Agricultural Technology Research Center

(5) The study of white rice blight disease by sero cidin -- Agricultural Technology Research Center

(6) The physical-chemical study of the glenical pharmacy of farm chemicals -- Agricultural Technology Research Center

(7) The improvement of auxiliary chemicals -- Agricultural Technology Research Center

(8) The chemical micro estimation method of new farm chemicals -- Agricultural Technology Research Center

(9) The confirmation of separation of new farm chemicals by the chromatographic method -- Agricultural Technology Research Center

(10) The assessment of effectiveness of organic synthetic insecticides -- Agricultural Technology Research Center

(11) The biochemical study of new farm chemicals -- Agricultural Technology Research Center

(12) The absorption and shift of γ-BHC in wet rice -- Agricultural Technology Research Center

(13) The diffusion of nematode-killing chemicals applied in soil -- Agricultural Technology Research Center

(14) The action of PCP in aqueous solution and in soil -- Agricultural Technology Research Center

D. Priority testing and research projects in the future

1. The study of farm chemicals effective in the unresolved fields of control

There is a need for vigorous promotion of study on farm chemicals that are applicable and effective in the control of the following: white rice blight disease, various kinds of soil damage, harmful insects resistant to chemicals, frequent occurrence of harmful insects on fruit trees, ulcers on citrus fruits, and study of grasses, because control in these areas has not yet been achieved.

2. Study on the improvement and utilization of farm chemicals.

Even farm chemicals that are already used for control have room for numerous improvements; for instance, those that are low-poisonous to humans and animals and of little harm to crops (such as nematode-killing chemicals that can be used for crops yet to be harvested). It is also necessary to study strongly selective chemicals that are effective on harmful insects, yet are harmless to natural enemy

insects; or on permeating farm chemicals that protect crops by application to parts of grasses that lead to withering.

3. Study on the application of antibiotics to farm chemicals

It has been proved that some antibiotics are extremely effective as germicides in agriculture. But the appearance of new chemicals that are effective in the control of white rice blight disease and virus diseases is hoped for. These materials, together with organic synthetic compounds, are important source materials for farm chemicals, and they need further study.

4. Study on the utilization of natural matter for farm chemicals

At present synthetic organic compounds form the main axis of farm chemicals, derris, nocotin, pyrethrine and other botanical insecticide ingredients are not given sufficient attention. But they all have respective characteristics, and in view of the discussion of the ills in the idea that synthetic farm chemicals are all powerful agents, the study and utilization of natural matter will again be the topic of discussion. Especially in the case of incentive agents and avoidance agents, they have learned from natural matter.

5. The relationship between the chemical structure and physical-chemical characteristics and effectiveness of effective matter

The clarification of the relationship between the empirically intensified chemical structure, and physical and chemicals: it is imperative that in the study of farm chemicals we endeavor to inquire into the establishment of theories concerning them.

6. Study on the analytic method of farm chemicals

The guarantee of farm chemicals is always done by the clear analytic method. The recent discovery of new chemical analytic methods and the progress in analytical instruments have been widely applied to the analytic method of farm

... Therefore, it is important to establish new analy- ... methods in farm chemicals by promptly applying the ... progress in analytical methods to farm chemicals. With the progress of the analytic method, all fields of the study of farm chemicals can make progress.

7. The chemical study of mixed farm chemicals

In the past, simultaneous control was widely used for fruit trees and the directions were provided by the mixing table. The request for the simultaneous spraying of insecticides and germicides has become strong of late, in view of the labor shortage in rice fields and the establishment of the aerial spraying method. Moreover, the mixing of various materials such as herbicides and fertilizers has been attempted. In this case the clarification and improvement of the chemical and physical impact due to mixing remain as a future problem. Especially the fact that a physical and chemical change of the main chemicals, due to the mixing of dilution agents of farm chemicals or emulsifiers, is possible and change with the passing of time during storage is possible present wide-range problems.

8. Study on the improvement of the galenical pharmacy of farm chemicals

The improvement and study of galenical pharmacy suitable for major chemicals has been constantly carried out. There are such fields in the improvement of galenical pharmacy as root penetration, water surface application, soil application, granule spraying and the utilization of mist, that are suitable to spraying equipment. Farm chemicals in tablet form and the automatic adjustment of chemicals are under consideration because of their simplified use. Insecticides that are of high concentration yet without adverse harm and hydrates of low viscosity have important characteristics for use in aerial spraying. Theoretical study to support the above studies must be continued.

9. Study on growth adjustment chemicals of plants

The study of herbicides, plant hormones, growth control chemicals, and drying chemicals, with the exception of herbicides, has markedly lagged. Even in the case of herbicides, their chemical and biochemical study must await progress

in the future. In view of trends in agriculture, the study of the merits attention.

10. Study of the action of farm chemicals in plants and soil

The action of farm chemicals has an extremely wide range. Their action in insects, pathogenic germs, and in grasses has been pursued from the aspect of application.

The action of farm chemicals sprayed in the air is examined solely in the spraying method. When it reaches the action point, study develops in the biochemistry and physics of farm chemicals. This realm forms a science boundary, and the overlapping study by respective specialists will be effective. It is significant research in the safe use of farm chemicals.

11. Study of the utilization of isotopes on farm chemicals

The utilization of isotopes has clarified such delicate aspects as the action, decomposition, and analysis of micro farm chemicals which are utterly impossible with other means. Its full adoption is difficult because of the control of its use and the elimination of contamination, but it should be developed as a powerful means of research.

12. Study of the protection and quality of harvested crops

In the past farm chemicals were solely used for the crops to be harvested, and there was a little interest in harvested crops. But since the quantity of farm products was secured and the taste of consumers changed, the quality and preservation of harvested crops became important. Because the use of farm chemicals decides the marketability of products, the impact of farm chemicals on the coloring, taste, flavor, and preservation of harvested crops will merit attention in the future. In the case of the fumigation of warehouses and the preservation of tangerines, the method of their use in many instances contain blind spots, ending their effectiveness.

15. Study on the improvement of spraying of farm chemicals

The improvement of the farm chemical spraying method requires cooperation from many fields. Recently, agriculture is in a position to actively accept effective spraying methods. And moreover, their efficiency is being improved in addition to the use of aerial spraying. The study of farm chemicals must catch up with this.

IV. AERIAL SPRAYING OF FARM CHEMICALS

A. A history of testing and research

The testing and research on the aerial spraying of farm chemicals commenced in 1953 when the system of cooperative research among the departments of insects, pathology, farm chemicals, and meteorology in the Agricultural Technology Research Center was formed and with the close liaison with the Hokkaido Agricultural Experiment Station and the good offices of the Ministry of Agriculture and Forestry, along with the cooperation of civilians. Beginning in 1954, the study of aerial spraying on wet fields was carried out with assistance in test and research funds for science by the Ministry of Education. For three years, by the organization of the research team composed of universities, concerned prefectures, the farm machine division of the Kanto Tosan Agricultural Experiment Station, and technicians from concerned firms, the study was conducted. At the same time, the Agricultural Technology Research Center cooperated with the testing by the Forestry Agency, Forestry experiment stations, forestry bureaus, and later concerned prefectures. On the other hand, basic research in this field was carried out with the cooperation from aircraft manufacturing companies, air lines and farm chemical companies.

B. Results of testing and research

(1) For the present helicoptors rather than fixed wing airplanes can be more widely used for wet fields, forests, and pastures in Japan.

(2) At present, several large types of helicoptors are not suitable in the aerial functions necessary for spraying and from the economic viewpoint.

(3) The dusting device, misting device, and granule spraying device have been developed to a point of becoming practical.

(4) Various aspects of aerial spraying are· Flying speed, 40-50 km per hour; flight altitude, 3-8 m (10m); effective spraying range (or flight interval), 18m.

(5) So far the practicality has been confirmed vis-a-vis wet rice, harmful insects and blights on fruit trees, in addition to insects harmful to forests.

C. Main testing and research topics undertaken at present

No institution is presently conducting research on aerial spraying as a research project. Actually, various state, prefectural and civilian organizations are independently or concurrently carrying on various tests in this field. Therefore the developmental committee composed of state and civilian researchers and other concerned experts has been established in the Agricultural, Forestry, and Fishery Aviation Association. It has guided the planning and execution of these tests and examined their results, with considerable accomplishments.

D. Priority testing and research projects in the future

The aerial spraying method is already in the practical stage, but the following research projects remain for the future:

(1) Study on the types of aircraft to be used for spraying: There is a need for re-examination of rotating wing craft as well as fixed wing craft.

(2) Study on the improvement of spraying devices:

While the spraying device is widely used, improvement is still required in the spraying method.

(3) Study on various dimensions of spraying flight:

In addition to the expansion of object harmful insects and the improvement of aircraft types and spraying devices,

spraying speed, altitude, intervals are posed as new research topics.

(4) Study on spraying materials:

The simultaneous use and mixing with other agricultural materials as well as new farm chemicals, new chemical types, and composition offer topics for research.

(5) Study on spraying technique:

New study is required because of the progress made in the control of harmful insects and blights (including progress in farm chemicals).

(6) Meteorological study on aerial spraying:

An inquiry into the clarification of the dynamic relationship between meteorology at the time of aerial spraying, and crops and micro flow entities.

(7) Study on the expansion of the application surface of aerial spraying and development:

The improvement of economy of aerial spraying including the comprehensive utilization of aircraft for agriculture and forests must be attempted.

(8) Study on the aerial spraying testing method:

Study on the improvement of the investigation method of effectiveness of aerial spraying is desirable.

V. SOME PROBLEMATIC POINTS IN THE ADVANCE OF TESTING AND RESEARCH

1. On the consolidation of research organization and system

The sector of harmful insects and blights is related to not only the aspects of cultivation and growth, but also to the transportation and storage of products. Therefore, all testing and research institutions concerned with the production of plants in agriculture and forestry have relavent realms in this sector and thus engage in research activities. Under this system mutually closely related research sections belong to separate institutions according to the different objects of research. Research itself is isolated and becomes fragmented and systematic and effective research becomes difficult. Accordingly, the following consideration on the consolidation of research organizations and systems is required in order to correct such defects and to solve effectively, problems confronting researchers.

It will be advisable to re-examine research topics, and approaches to them related to basic research. This must be developed urgently and with priority in the future. Moreover, the method, organization, and management of research at the Agricultural Technology Research Center, which is mainly in charge of research, must be scrutinized so as to more effectively carry out basic and common research and to consolidate the system for the closer coordination among different research institutions, for the systematic and effective execution of various aspects of research from base to application and practice. This must be pointed out, especially in the new fields of research that form special research realms, as the research on plant viruses, utilization of natural enemies, and harmful nematodes.

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2. On the strengthening of research that is presently necessary

The following apparently should be taken into consideration in order to gradually consolidate the organization and system of research in accordance with the afore-mentioned basic direction and to solve many important problems following the current improvement in agricultural structure.

(1) The strengthening of research on the utilization of natural enemies

Research on the utilization of natural enemies covers a wide range, including farming, horticulture, livestock industry, and forestry. With the enhanced importance of research in recent times, research techniques have become highly sophiscated, and their ramifications felt in new fields with particular research realms. Accordingly, it is necessary to re-examine and consolidate the organization of the Agricultural Technology Research Center for the future development of research, and to strengthen research on the utilization of natural enemies in the fields of farming, horticulture, livestock industry, and forestry as well.

(2) The strengthening of research organization on harmful nematodes

The research on harmful nematodes has become more and more important, as in the research on natural enemies. The research itself is being carried out in particular fields. But only the Agricultural Technology Research Center, the Horticultural Experiment Station, and the Hokkaido Agricultural Experiment Station are capable of carrying out research on harmful nematodes. Therefore, consolidation and strengthening of the research organization and system in this field at the afore-mentioned institutes are required. The strengthening of research on the control of nematodes in horticultural crops and warm zone dry field crops is particularly urgent.

(3) The strengthening of research on plant virus diseases

As the importance of the study of plant viruses was recognized, the Plant Virus Research Center was established in 1963 as an institution in charge of the basic research of plant viruses. Thus the consolidation of organization and system in line with the afore-mentioned aim has been

carried out. In addition to this, it will be necessary to strengthen the research on the application and practice of control of particular viruses on fruit trees, vegetables, flowering plants, timbers, and dry field crops in horticulture and forestry.

(4) The strengthening of research on the harmful insects and blights of dry field crops

There is one research section each, on the diseases of dry field crops, at the Tohoku Agricultural Experiment Station and Kyushu Agricultural Experiment Station, and one research section each, on harmful insects, at the Hokkaido Agricultural Experiment Station and Tohoku Agricultural Experiment Station. All of them, however, are weak. Therefore in order to powerfully promote the research in this field it will be imperative to strengthen the research organization and system on harmful insects and blights of general dry field crops, pasture grasses, fodder crops, and tea.

(5) The strengthening of research on farm chemicals

There are five research sections in the Department of Farm Chemicals, Division of Pathology and Entomology, Agricultural Technology Research Center. It is desirable, to meet the new situation in the future, to strengthen the organization of the Agricultural Technology Research Center as well as to strengthen the application and practical use in the fields of farming, horticulture, forestry, and utilization and processing, thus systematically and effectively promoting research while maintaining close mutual cooperation.

3. On the consolidation of special machines and facilities

For the testing and research on harmful insects and blights, isolated hot houses with simple air conditioning and heating, screen houses to shut out carrier insects, isolated experiment sites are needed for soil insects, blights and nematodes, and high pressure sterilizing machines, breeding rooms for breeding experiments on harmful insects and the breeding of test insects, mobile research vans (Laboratories), and other special machines and facilities are required. But, as these machines and facilities require a large amount of investment, they are not generally available. For the effective promotion of research, it is strongly desired that priority be given to the installment of these machines and facilities in addition to the consolidation of organization and system.

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APO San Francisco, California

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